Supplier Document Status Stamp

BSC

A. Records Designator: ☐ QA: QA ☒ QA: NA

B. LSN Relevancy: ☐ LSN Relevant ☒ Not LSN Relevant

C. Privileged or Copyright Protected: ☐ Yes ________ ☒ No

D. Procurement Document No. NHC4-00207

E. BSC Standard Document No. V0-A000-NHC4-00207-00001-001-003

F. SUPPLIER DOCUMENT STATUS

1. ☒ WORK MAY PROCEED.
2. ☐ REVISE AND RESUBMIT. WORK MAY PROCEED SUBJECT TO RESOLUTION OF INDICATED COMMENTS.
3. ☐ REVISE AND RESUBMIT. WORK MAY NOT PROCEED.
4. ☐ REVIEW NOT REQUIRED. WORK MAY PROCEED.
5. ☐ FOR INFORMATION ONLY.

PERMISSION TO PROCEED DOES NOT CONSTITUTE ACCEPTANCE OR APPROVAL OF DESIGN DETAILS, CALCULATIONS, ANALYSES, TEST METHODS, OR MATERIALS DEVELOPED OR SELECTED BY THE SUPPLIER AND DOES NOT RELIEVE SUPPLIER FROM FULL COMPLIANCE WITH CONTRACTUAL OBLIGATIONS.

G. REVIEW COPY	NVM	NE											
	ECA	KAM											

H. Area Code NA System Code NA Baseline Level NA

I. DOCUMENT CATEGORY NA

(Attach 3, Attach 4, or SSRS Form as applicable)

J. Eugene C. Allen ECAllen 6/14/07

RESPONSIBLE ENGINEER/ANALYST (Printed Name and Signature) DATE

Title: Hydrologic and Drainage Evaluation Report Caliente Rail Corridor (without markings)

Supplier Document #: N/A

Supplier Rev.: 0

Supplier Date: 06/27/05

Reference#: NVT-CD-00159

NVM Nevada Transportation Manager Gene Allen
NE Nevada Engineering Kathy Mrotek

Note: Document resubmitted to remove privileged markings only. No technical changes were made.

BSC

Supplier Document Distribution

Complete only applicable items.

QA: N/A

1. Supplier/Subcontractor Name:	Purchase Order/Subcontract No. and Title:	
Parsons Brinkerhoff	NN-HC4-00207	
2. BSC Submittal No.: V0-A000-NHC4-00207-00001-001	Revision: 003	Title: Hydrologic and Drainage Evaluation Report Caliente Rail Corridor (without markings)

Responsible Individual:	Eugene Allen	EA	423	06/11/07	06/15/07
	Name (Print)	Initials	Mailstop	Date	Due Date

DISTRIBUTION

Discipline/Organizations	Abbrev.*	3. Name	Mailstop	4. For Review	5. After Acceptance
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H
				☐	☐ E ☐ H

6. Document transmitted contains OUO information? ☐ Yes ☐X No

*** Use these abbreviations on the Supplier Document Status stamp to indicate reviewers.**

BSC

Transportation Data Pedigree Form

Complete only applicable items.

Subcontractor:	Item Number/Title/Revision:	Submittal Date:	SRCT No.:
Parsons Brinckerhoff	Hydrologic and Drainage Evaluation Report - June 27, 2005	May 15, 2007	~~07-00022~~ 07-00132

05-25-07

Section I. Submittal Information (includes above information)

Submittal Description and Revision Summary for Entire Submittal:

This submittal is a re-submittal due to the letter received from BSC dated May 1, 2007 requesting modification (removing "pre-Decision EIS related" markings) to the original submittal.

Special Instructions:

Section II. Data File Information (Add lines below if needed for additional files. Indicate "Last item" or "End of list" on last line used.)

Filename	Rev.	File Size	Description (File description and revision summary for file)	Application and Version/ Add-in or Extension and Version
Fig1_1_GenLocMap3_22x34_20050621.pdf	00	14,326 KB	General location map	Adobe Acrobat 7.0 Professional
Fig3_1_hdsc_nws_noaa100yr06hr_22x34_20050621.pdf	00	1,365KB	NOAA 100-year, 6 hours rainfall information	Adobe Acrobat 7.0 Professional
Fig3_2_hdsc_nws_noaa100yr12hr_22x34_20050621.pdf	00	1,443KB	NOAA 100-year, 12 hours rainfall information	Adobe Acrobat 7.0 Professional
Fig3_3_TemporalDistrRegions_22x34_20050621.pdf	00	1,433KB	Temporal Distortion in Southwest region	Adobe Acrobat 7.0 Professional
Fig3_4_Precip_Stations24x36_20050614.pdf	00	501KB	Precipitation station location map	Adobe Acrobat 7.0 Professional
Fig3_5_CRC_StreamGaugeStations_22x34_20050621.pdf	00	598KB	Guage station location map	Adobe Acrobat 7.0 Professional
Fig3_6_Field_Verified_Vegetation22x34_20050621.pdf	00	5,093KB	Field vegetation verification map	Adobe Acrobat 7.0 Professional
Fig3_7_CRCSoils_22x34_20050621.pdf	00	1,651KB	Soil map	Adobe Acrobat 7.0 Professional
FIG5_1_ProjWatershedMap_11X17_20050621.pdf	00	295KB	Project watershed map	Adobe Acrobat 7.0 Professional
Final report.pdf	00	209KB	Final report in pdf format	Adobe Acrobat 7.0 Professional
Report Cover - Back PB.pdf	00	148KB	Report cover – Back	Adobe Acrobat 7.0 Professional
Report Cover - PB.pdf	00	326KB	Report cover – Front	Adobe Acrobat 7.0 Professional
Report Cover - Spine.pdf	00	362KB	Report cover - Spine	Adobe Acrobat 7.0 Professional

Section III. Metadata

☒ **GIS Metadata**	Projection:

BSC	**Transportation Data Pedigree Form** *Complete only applicable items.*	QA: N/A Page 2 of 2

Subcontractor:	Item Number/Title/Revision:	Submittal Date:	SRCT No.:
Parsons Brinckerhoff	Hydrologic and Drainage Evaluation Report - June 27, 2005	May 15, 2007	~~07-00022~~ 07-00132

05 5-25-07

All GIS data is preferred in ArcGIS9.1 UTM, NAD1983, Zone11, Feet.	
	Zone:
	Units:
☐ **CAD Metadata** CAD drawings are preferred in **Bentley MicroStation V8 and/or InRoads** and should adhere to established **CAD standards**.	Level descriptions:
	Scale:
	Units of Measurement:
	Horizontal and Vertical Datum:

Section IV. Data Screening (Completed by BSC personnel)

Suitable for Review?	Screener Name:	Signature:	Date:
☒ Yes* ☐ No	Cathy Stettler	Cathy Stettler	5/25/07

*If "Yes", Data Storage Location: Nvtdata\PB\Phase 1\07-00132 Hydro and Drainage Eval Rpt CRC Rev 00

Comments: *(Justification for rejecting submittal is **required**; other comments are optional.)*

06-07-05
Per Direction from NV Transportation management revision 00 is being resubmitted without privileged markings.

Section V. STR Disposition of Submittal

Process for Review?	** If "No", date returned:	Comments:
☐ Yes ☐ No**		
STR Name: EUGENE C. ALLEN	Signature: E C Allen	Date: 5/30/07

KAM 5/29/07

Hydrologic and Drainage Evaluation Report

Task 2.6
REV. 0 June 27, 2005

Prepared by:

Prepared for:

Caliente Rail Corridor Hydrologic Analyses

Subcontract NN-HC4-00207

27 June 2005

HYDROLOGIC AND DRAINAGE EVALUATION REPORT

CALIENTE RAIL CORRIDOR
YUCCA MOUNTAIN PROJECT, NEVADA

Subcontract No. NN-HC4-00207

June 27, 2005

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Acronyms and Abbreviations

Original Name	Acronym
American Association of State and Highway and Transportation Officials	AASHTO
American National Standards	ANS
American Railway Engineering and Maintenance-of-Way Association	AREMA
Bechtel SAIC Company	BSC
Bureau of Land Management	BLM
Caliente Rail Corridor	CRC
Comprehensive Environmental Response, Compensation, and Liability Act	CERCLA
Civilian Radioactive Waste Management System	CRWMS
Code of Federal Regulations	CFR
Curve Number	CN
Department of Energy	DOE
Digital Elevation Model	DEM
Digital Image Rectification System	DIRS
Digital Video Disk	DVD
Energy Research & Development Administration	ERDA
Environmental Impact Statement	EIS
Executive Order	EO
Federal Emergency Management Agency	FEMA
Federal Highway Administration	FHWA
Geographic Information System	GIS
Global Positioning System	GPS
Hydrologic Engineering Center	HEC
National Environmental Policy Act	NEPA
National Flood Frequency	NFF
National Flood Insurance Program	NFIP
National Oceanic & Atmospheric Administration	NOAA
National Pollutant Discharge Elimination System	NPDES
Natural Resources Conservation Service	NRCS
Nevada Administrative Code	NAC
Nevada Department of Transportation	NDOT
Nevada Revised Statutes	NRS
North American Datum	NAD
North American Vertical Datum	NAVD
Soil Conservation Service	SCS
Triangulated Irregular Network	TIN
United States Bureau of Reclamation	USBR
United States Geological Survey	USGS
United States of America Corp of Engineers	USACOE
Universal Transverse Mercator	UTM

1.0 INTRODUCTION

1.1. PROJECT BACKGROUND

The Caliente Rail Corridor (CRC) will cross numerous streams and small drainages. Most of these are ungaged, meaning that no measurements of flood flows have ever been made. In fact, few stream flow measurements have been made in this arid region. Thus there is a need to use computer models that simulate the hydrologic process that can result in flooding to a railroad corridor. The general goal of this modeling is to determine a reliable estimate of flood discharges and stream elevation so that the railway can be placed above flood elevation, provide adequate waterway crossings, and not be damaged by stream erosion and other stream forces.

The design of the CRC will follow standards of the transportation industry as compiled by the following institutions:

- American Railway Engineering and Maintenance-of-Way Association (AREMA)
- American Association of State and Highway and Transportation Officials (AASHTO)
- Federal Highway Administration (FHWA)
- Nevada Department of Transportation (NDOT)

According to these references, the 50-yr flood frequency is often used for evaluating the hydrologic reliability of rural transportation corridors. Other flood frequencies that are important in the design of transportation corridors include the 100-yr frequency in accordance with the National Flood Insurance Program (NFIP) and the 500-yr frequency for bridges that are scour vulnerable. In addition, arid region stream morphology is associated with more frequent floods in the range of the 10-yr flood.

1.2. PURPOSE AND SCOPE

The objectives of the hydrologic investigations are to:

1. Support the preparation of an Environmental Impact Statement (EIS) by identifying locations of significant and unusual flood hazards (i.e., those parts of the corridor potentially affected by severe flash floods, extensive mudflows, and areas of standing water such as playas).

2. Provide data and analyses to support route selection and alignment optimization and the conceptual design of a rail line within the Caliente Corridor.

3. Specify and apply a watershed model approach, based on a 100-yr flood recurrence interval, to identify flood-runoff characteristics of the watersheds along the Caliente

Corridor. Results from this work will be used by others in the conceptual, preliminary, and final design of the drainage structures along the alignment under consideration.

4. Develop surface drainage recommendations and move forward with the modeling in Phase II of the project.

5. Provide services to analyze and review drainage structures during the design/build or construction phase of the railroad.

2.0 DRAINAGE REGULATIONS

2.1 DRAINAGE REGULATIONS

The proposed Caliente Rail Corridor (CRC) originates near Caliente, Nevada, and travels west, south and east, traversing the Chief, North Pahroc, Golden Gate, and Kawichs Mountain Ranges, as well as traversing near the towns of Goldfield, Scottys Junction, and Beatty and ending at Yucca Mountain. The corridor currently under investigation traverses three counties (Lincoln, Nye and Esmeralda), and over 90% of the lands associated with the Caliente Corridor are public land managed by Bureau of Land Management. Due to the fact that the corridor route passes through the three counties within the State of Nevada and federal lands, there are federal, state, and local drainage laws, regulations and rules that may apply to the drainage design along the corridor. This section attempts to identify the most relevant of these regulations. Other regulations may become applicable during the process of this study and, if so, will be included herein.

2.2 FEDERAL REGULATIONS

Federal regulations include the Code of Federal Regulations (CFR), Executive Orders (EO) and department and agency rules. The following lists the most significant of these regulations.

- 44 CFR Part 9 – Floodplain Management and Protection of Wetlands

  This regulation affects the rail corridor elevation design and hydraulic structure sizing for segments crossing floodplains. If wetlands are impacted, protection and/or replacement measures are necessary.

- 44 CFR Part 60 – Criteria for Land Management and Use

  This federal regulation concerns flood plain management and flood-prone and mudslide areas.

- 44 CFR Part 65 – Identification and Mapping of Special Hazard Areas

  This federal regulation concerns flood hazard identification, revision and review.

- 10 CFR Part 1022 – Compliance with Floodplain/Wetlands Environmental Review Requirements

  This part establishes policy and procedures for discharging the Department of Energy's (DOE's) responsibilities under EO 11988 and EO 11990, including: (1) DOE policy regarding the consideration of floodplain and wetland factors in DOE planning and decision-making; and (2) DOE procedures for identifying proposed actions located in a floodplain or wetland, providing opportunity for early public review of such proposed actions, preparing floodplain or wetland assessments, and issuing statements of findings for actions in a floodplain.

To the extent possible, DOE shall accommodate the requirements of EO 11988 and EO 11990 through applicable DOE National Environmental Policy Act (NEPA) procedures or, when appropriate, the environmental review process under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601 et seq.).

- EO 11988 – Floodplain Management
- EO 11990 – Protection of Wetlands
- DOE Order 6430.1A – General Design Criteria

The provisions of this Order apply to all Departmental Elements except as otherwise provided by statute or by specific delegation of authority from the Secretary of Energy, and all contractors and subcontractors performing work for the Department whose contract may involve planning, design, or facility acquisitions. This includes DOE-owned, -leased, or -controlled sites where Federal funds are used totally or in part, except where otherwise authorized by separate statute or where specific exemptions are granted by the Secretary or his designee.

- DOE-STD-1020-94 – Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy (DOE) Facilities

This design and evaluation criteria control the level of conservatism introduced in the design/evaluation process such that earthquake, wind, and flood hazards are treated on a consistent basis.

- Bureau of Land Management (BLM) Right-of-Way regulations

This is the BLM rules of right-of-ways. It may be applicable to channel realignments.

Table 2-1.

Referenced Flood Events and other Information Referenced in Federal Regulations

Regulations	25-yr	100-yr	500-yr	PMF	Sediment Transport	Notes
DOE Order 6430.1A	X	X	X	X	X Also implied	References: EO 11988, EO 11990, 10 CFR Part 1022, UCRL 115910
DOE-STD-1020-94				X	X	

Regulations	25-yr	100-yr	500-yr	PMF	Sediment Transport	Notes
EO 11988		X				
EO 11990						Wetlands
44 CFR Part 9		X	X		Implied by references to other regulations	
44 CFR Part 65		X	X		X	Also FEMA Design Criteria Chapter 10
10 CFR Part 1022		X	X			
40 CFR Part 264.18		X				
40 CFR Part 264.193	X					Based on a 24 hr storm event
40 CFR Part 270.14		X				Requirement for flood hazard delineation map and consideration of other "special flooding"

The current scope of this project only addresses the 100-yr flood event with various durations depending on hydrologic area and other factors. Sediment transport is to be addressed only in those areas where such transport will affect the design of the CRC improvements.

2.3 STATE REGULATIONS

State regulations are administered through different state agencies. The following lists the relevant state agencies and their most relevant regulations.

Nevada Department of Conservation and Natural Resources

- NRS 543 CONTROL OF FLOODS

  This NRS chapter concerns the cooperation of the state of Nevada with federal agencies.

Nevada Division of Water Resources

- NRS 535 Dams and other obstructions

  This regulation affects dams and other obstructions design. If impounding of more than 20 AF of water and/or mud, or the obstruction structure is greater than 20 ft, review and permitting are needed with the Nevada Division of Water Resources. Section 5.7.5 identifies that there are several reservoirs in the CRC watersheds that may affect the drainage design of the railroad.

Nevada Division of Environmental Protection

- NPDES Permit (NRS 445A)

  This regulation concerns the quality of storm water discharge. Best Management Practices (BMPs) should be implemented so that the rail corridor activities should not pose any threat to storm water quality. Channel design and construction need to consider erosion control measures.

Nevada Department of Transportation

- Terms and Conditions Relating to the Drainage Aspects of Right-of-Way Occupancy Permits

  This concerns discharges and/or impacts to the NDOT properties and right-of-ways.

2.4 LOCAL REGULATIONS

Nye County Code

- Chapter 15.12 Flood Damage Prevention

  This code requires any development to mitigate negative flood impacts.

Lincoln County Code

- Title 17 Development Code

  This code requires any development to mitigate negative flood impacts.

Esmeralda County

- No building permit requirement.

3.0 LITERATURE AND DATA REVIEW

3.1 HYDROLOGIC REPORTS AND ANALYSIS

Several analyses and reports have been prepared which present hydrologic analysis of areas in and around the CRC watershed area. Many of these analyses and reports are documented in the Hydrology Report prepared in 1990 for the initial conceptual design of the Yucca Mountain access railway (KJC, 1990). Floodplain mapping information collected from these existing studies is included in the hydrologic data DVD which contains relevant collected data for this hydrologic study.

The most pertinent of these studies include KJC, 1990, as well as relevant studies completed since 1990 or not included in KJC, 1990 are as follows:

3.1.1 Hydrology Report - Yucca Mountain Rail Access Study – Caliente Route, Kennedy/Jenks/Chilton, December 1990 (KJC, 1990)

This study was prepared to provide hydrologic data to be used in the conceptual design of the Yucca Mountain access railway. Some of the alignments analyzed in this study are similar to those being analyzed in the current study. This study determined peak 100-yr runoff flow rates for about 150 separate watersheds using the USACOE HEC-1 computer program. For watersheds from 1 to 5 sq mi, the study used two separate regression equations generated from the HEC-1 analysis; one equation for alluvial watersheds and one for normal watersheds. The study also provided information and 100- yr peak flow rates for FEMA regulated floodplains and expected flood levels in Mud Lake.

3.1.2 United States Geological Survey (USGS) Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States (USGS, 1994 and 1997)

This study presents equations for estimating 2-, 5-, 10-, 50-, and 100-yr peak flow rates for ungaged sites on unregulated streams that drain watersheds of less than 200 sq mi. Specifically, the CRC watersheds are located almost exclusively within two of the USGS designated Hydrologic Flood Regions. These regions overlap with one region located at or below 7500 ft in elevation (Region 6) and the other region (Region 1) located above 7500 ft in elevation. The 7500 ft elevation threshold represents an estimated elevation above which large flood events caused by thunderstorm events are unlikely to occur. This is thought to be due to the reduced amount of energy and moisture available at higher elevations for the convective process and the greater density in ground cover which enhances infiltration and reduces runoff. Region 6 (including the overlaying Region 1) encompasses almost one-half of the State of Nevada and the western half of the State of Utah.

The only CRC watershed area not located in Regions 1 or 6 is the area south of latitude 37° (along CRC segments CS7, BW1, BW3 and CS6). This watershed area is located in Region 10 which encompasses the southern quarter of the State of Nevada (all areas south of 37° latitude) including all of Clark County (Las Vegas Metropolitan area). The equations presented in this study show that peak discharges in Region 10 are much higher than peak discharges in Region 6 for the same drainage area, especially for larger watersheds. This study also suggests that, while the region boundaries are explicit for purposes of equation generation, the actual hydrologic boundaries are not necessarily distinct. Thus, areas near these boundaries, such as is the case for the above described CRC segments in Region 10, should be analyzed using both regions equations and weighted accordingly.

3.1.3 Clark County Regional Flood Control District Technical Memorandum No. 2, WRC Engineering, Inc., December, 1989 (WRC, 1989)

This study provides a comprehensive analysis of rainfall statistics and patterns in the Clark County, Nevada area. The study provides meteorological analysis of storm types occurring across the southern Nevada area and includes analysis of rainfall data from several stations located within the Nevada Test site.

3.1.4 National Oceanic & Atmospheric Administration (NOAA) Atlas-14 (NOAA, 2004)

NOAA Atlas 14 is the most current and in-depth study of precipitation patterns and statistics for the southwestern United States. This study is a replacement for NOAA Atlas 2 which was published in 1973. NOAA Atlas 14 includes over 20 years of additional precipitation data subsequent to NOAA Atlas 2. Presented on Figures 3-1 and 3-2 are NOAA Atlas 14 precipitation maps for the State of Nevada for the 100-yr storm event with durations of 6 hours and 24 hours.

Appendix A.1 of NOAA Atlas 14 includes an analysis of temporal distributions of heavy precipitation in the NOAA Atlas 14 study area. For this analysis, the study area was divided into two sub-regions based upon the seasonality of observed heavy precipitation events. In Nevada, the boundary between general precipitation events (to the north) and convective (thunderstorm) precipitation events (to the south) approximately extends from the middle of Nye County at the California border to the middle of Lincoln County at the Utah border. In general terms, this follows the similar region boundary discussed in the USGS report (USGS 1997). This study concluded that maximum precipitation events in the general precipitation area were dominated by cool season (winter) precipitation while maximum events in the convection precipitation area occurred in the warm (summer) season as shown on Figure 3-3. This finding from this study can be applied to the selection of temporal distributions of precipitation and the determination of modeling parameters to estimate runoff characteristics for design purposes.

3.1.5 Federal Emergency Management Agency (FEMA) Flood Insurance Studies

This study reviewed and obtained the FEMA, USGS, and other sources of data to determine who has prepared flood maps or flood studies within the CRC. Based on the research of the available data, the only flood map or flood studies located were completed for FEMA.

The FEMA has conducted the following flood insurance studies for Nye County, Lincoln County, and the City of Caliente, Nevada.

1. Flood Insurance Study, City of Caliente, Nevada, October 1985 (FEMA, 1985)
2. Flood Insurance Study, Lincoln County, Nevada, February, 1988 (FEMA, 1988)
3. Flood Insurance Study, Nye County, Nevada, June, 1998 (FEMA 1998)

These studies provide peak flow estimates for the White River and the Meadow Valley Wash. Floodplains and floodways are also presented on the associated Flood Insurance Rate Maps for portions of the White River and Meadow Valley Wash in the vicinity of the CRC. Maps of approximate floodplain areas are also available from FEMA covering areas of Nye County.

3.1.6 Final Hydraulic Design Report for Amargosa River Bridge (WRC, 1993)

This study provides an analysis of peak flows of the Amargosa River at the river crossing of U.S. 95 north of Beatty, Nevada. The analysis used various methods of peak flow estimation to establish the 100-yr peak flow for an NDOT bridge replacement project.

3.2 HYDROLOGIC DATA

3.2.1 Precipitation Data

Daily precipitation data in the CRC watershed is available from thirteen weather stations (See Figure 3-4). Most of these weather stations have less than 50 years of daily data. The stations which have more than 50 years of data include the Goldfield, Adaren, and Pioche weather stations. Analysis and regionalization of this data is including in the NOAA Atlas 14 (NOAA, 2004). Additional precipitation data is available for the Nevada Test site weather stations.

3.2.2 Streamflow Data

Relevant streamflow data in and near the CRC watershed is available from eighteen stream gauging stations (see Figure 3-5). Of these stations, only 8 stations have sufficient data from which a statistical streamflow relationship can be defined.

Analysis of data from these stations through 1985 is presented in USGS, 1997. The gauging data is contained in the hydrologic data DVD for this project.

3.3 HYDROLOGIC RELATED DATA

3.3.1 Topography

30-m digital elevation model (DEM) data is available from the USGS for the entire study area. In addition, USGS 7.5 minute quadrangles are also available for the entire study area.

3.3.2 Aerial Photography

Detailed aerial photography at a scale of 1 m per pixel from 1999 is available from the USGS for the entire study area excluding the Nevada Test and Training Range.

3.3.3 Vegetation and Land Use

Detailed vegetation and land use coverage data is available from the USGS for the entire study area. In addition, more current and detailed provisional vegetation and land use coverage data is available from the USGS's cooperative Southwest Regional Gap Analysis Program (USGS, 2004) (see Figure 3-6).

The vegetation and land use data will be field-verified and utilized to determine runoff modeling parameters. Field verification will identify changes of vegetation conditions and land uses since the time the USGS data coverages were developed.

3.3.4 Soils

Soils information for the entire study area is available from the NRCS (see Figure 3-7). The soils information for the study area obtained was in a GIS coverage, which included the soils type, number and composition type. The information also included the SCS runoff classification type, which is A, B, C, or D type of soils. This information will be used to determine the runoff potential for the soils in the modeling phase of the project.

4.0 REGIONAL PRECIPITATION

4.1 INTRODUCTION

The watersheds which contribute runoff to the CRC are all located in an area generally described as the Great Basin Desert. The climate of this area consists mainly of warm to hot, dry summers and cool to cold, dry winters. In hydrologic terms, this climate results in two distinct hydrologic seasons. During the late spring to early fall season, precipitation patterns are dominated by convective, short duration, high intensity thunderstorm events. During the late fall to early spring season, precipitation patterns are dominated by long duration, low intensity, general storm events with both rain and snow possible throughout the study area. These two different types of precipitation events result in runoff events which differ between smaller watersheds (up to 200 sq mi) and larger watersheds (greater than 200 sq mi). For smaller watersheds, the summer thunderstorm events will dominate the peak runoff rates which occur in the tributary channels and washes. However, as the watersheds are increased, the general storm events eventually dominate the peak rates of runoff. In addition, for all watersheds, the volume of runoff will generally be greater for the general (winter) storm events than for the thunderstorm (summer) events. These differences will require hydrologic analysis of both thunderstorm events and general storm events to determine the controlling event for peak runoff rates and volumes.

4.2 CHARACTERISTICS OF FLOOD EVENTS IN NEVADA

A majority of the large flood causing events in and around the CRC on smaller watersheds are the result of summer thunderstorm events. These short duration, high intensity events have caused significant flood damage on various watersheds both in and surrounding the study watersheds. Examples include:

- A flood event on August 1, 1968, on the Amargosa River tributary (111 sq mi) near Mercury, with a recorded peak flood flow of 3430 cfs (31 cfs per sq mi).
- A flood event on July 29, 1975 on Caselton Wash near Panaca (70 sq mi), with a recorded peak flood flow of 1710 cfs (24 cfs per sq mi).
- A flood event in July, 1984 on Yucca Wash near Mouth (17 sq mi), Nevada Test site, with a recorded peak flood flow of 940 cfs (55 cfs per sq mi).
- A flood event in July 31, 1968 on Patterson Wash tributary near Pioche (5 sq mi), with a recorded peak flood flow of 49 cfs (10 cfs per sq mi).

Historic floods in the larger watersheds have been caused by both short duration, high intensity, summer thunderstorms and by long duration, continuous winter general storms, including rain on snow events. For the larger watersheds (greater than 200 sq mi.), historic peak flood flows are dominated by general storm events. Examples of these types of events include:

- A flood event on February 24, 1969, on the Amargosa River near Beatty (470 sq mi.), with a recorded peak flood flow of 16,000 cfs, (34 cfs per sq mi.).

- Several flood events on the Meadow Valley Wash near Caliente (1670 sq mi.), including 1910, 1938 and several other events including the most recent event of January 10, 2005. The estimated peak flood flow from these events were approximately 11,000 cfs (7 cfs per sq mi), 15,000 cfs (9 cfs per sq mi), and about 3000 cfs (1.8 cfs per sq mi), respectively.

- A flood event on March 11, 1995, on Fortymile Wash at the Narrows (258 sq mi.), Nevada Test Site, with a recorded peak flood flow of 3000 cfs (12 cfs per sq mi).

4.3 MOISTURE SOURCES AND FLOW PATTERNS

There are three important sources of moisture in the lower atmosphere which can supply the sufficiently "rich" moisture quantities needed to generate large precipitation events over the subject watersheds. The first source is from "summer monsoon" air originating in the Gulf of Mexico. This air moves in a broad path from the Gulf of Mexico toward the Northwest across Mexico, thence turns northward, northeasterly and, ever increasingly eastward across Arizona and Utah and furnishes abundant moisture for the many July and August rain showers in the states of Arizona, New Mexico, Utah, and Colorado, particularly in the mountainous areas. The very western edge of this monsoon flow moves northward over southeastern Nevada, but with less frequency than the main flow over Arizona and Utah. In addition, a moisture gradient exists in the monsoon flow which delivers less moisture to the north and central areas of Nevada than is provided along the southeastern border of Nevada.

The second source of moisture "rich" air originates in the Gulf of California. This air flows directly from south to north and covers over 400 miles or so to the southern Nevada area in durations in excess of 24 hours. This moisture pattern occurs infrequently as compared to the summer monsoon moisture pattern. In addition, the moisture content of this air decreases as the air mass moves from south to north.

The third source of moisture originates in the eastern Pacific Ocean. During the winter months, this significant source of moisture produces heavy rainfall in western California and heavy snowfall in the Sierra Nevada Mountain range. Moisture which remains is carried over the state of Nevada and produces general storm rainfall over the lower elevations for periods from 24 to 96 hours. Smaller periods of more intense precipitation are imbedded in these storms which, when combined with saturated ground conditions, create the winter flooding events characteristic of the large watersheds in the study area. At higher elevations, this moisture also precipitates as snow which can and has resulted in historic flooding events from "rain on snow". On rare occasions, during the summer months, warm moist air can move from the warm eastern Pacific Ocean above the limited passages that avoid high terrain in Southern California and produce general storms over broad areas for extended periods of time of 12 to 36 hours.

In addition to these three sources, a fourth source of moisture occurs in rare instances. This source is from dying hurricanes and tropical storms which generally occur during the month of September. These storms are similar to the eastern Pacific Ocean moisture flows in that they produce general storms which extend for 12 to 36 hours over a broad area of land. These storms, however, do not generally produce large intense, flood causing rainfall within the subject watersheds.

4.4 GENERAL STORM EVENTS

General storm events in Nevada are typically 2 to 4 day events with heavier precipitation occurring for only a short (3 to 6 hour) period during the storm events. NOAA, as part of their updated precipitation Atlas 14 for the southwest United States (NOAA, 2004), analyzed over 1800 storm events to determine temporal distributions of general storm events (see Figure 3-2). This analysis shows that over 45 % of the general storm events resulted in the period of heaviest rainfall occurring in the first 24 hours, with a majority of the heavy rainfall occurring in the first 12 hours. In general, the largest general storm flood events in central and southern Nevada have occurred after the initial storm precipitation has saturated the ground surface prior to the heaviest portion of the general storm event. The area extent of the general storms occurring in southern and central Nevada has typically ranged from 1000 to 10,000 sq mi.

4.5 THUNDERSTORM EVENTS

Thunderstorm events in Nevada are typically high intensity, short duration (1 to 3 hour) events occurring infrequently in the early spring to early fall months. NOAA, as part of their updated precipitation Atlas 14 for the southwest United States (NOAA 2004), analyzed over 2100 storm events to determine temporal distribution of thunderstorm events (see Figure 3-1). This analysis shows that over 50% of the storm events resulted in the period of heaviest rainfall occurring in the first one and one-half hours of the storm event, with a majority of the heavy rainfall occurring in the first hour. For these events, the ability of the ground surface to absorb and infiltrate rainfall is small as compared to the intensity of rainfall at the height of the storm event. These conditions provide the "flash flood" events typical of the smaller watersheds in the study area. The areal extent of thunderstorms typically covers less than 200 sq mi.

4.6 FREQUENCY OF EVENTS

The aridness of the CRC watersheds area is directly related to the lack of storm events occurring on a yearly basis. In fact, many areas will not experience a large storm event for several years. However, when storm events do occur, they tend to be severe and cause significant runoff to occur in the area washes and channels. The main risk to CRC facilities is thus governed by large, single events as opposed to more frequent, continuous events. Another risk to CRC facilities near dry lake beds is flood volume accumulated at the dry lake beds due to wet winter season storms over a long duration or due to large intense storm events with a short duration. There are some high elevation areas of the CRC watersheds which experience more continuous runoff during the winter and early spring months due to snowmelt and continuous low intensity rainfall. The peak runoff rates from these conditions are much lower than those caused by higher intensity general storm events and high intensity thunderstorm events.

5.0 CRC WATERSHEDS HYDROLOGIC CONDITIONS

5.1 TOPOGRAPHY

The general topography of the CRC watersheds consists of higher altitude mountainous areas draining to alluvial outflows and dry lake beds. Elevations in the watersheds range from above 9000 ft in the northern and mid-Nevada mountains to about 4500 ft in the alluvial flats around Yucca Mountain. Most of the mountain ranges exhibit a north-south orientation.

5.2 SOIL DRAINAGE CHARACTERISTICS

The soil characteristics of the CRC watersheds are reflective of the geology of the area. Much of the lower elevation watersheds consist of "desert pavement" (The layer of gravel or stones left on the land surface in desert regions after removal of the fine material by wind). In some areas, the soils are underlain by cemented hardpans (cemented by iron oxide, silica, calcium carbonite, or other substances). Several of the watersheds include areas of rock outcrops and larger stones and boulders. Predominate in most of the drainage areas are soils classified as Hydrologic Soil Group C and D soils. These soils have reduced infiltration capacity as compared to more pervious Group A and B soils.

5.3 LAND USE

Over 90% of the CRC watersheds consist of undeveloped government and private land. Typical uses of this land are for military exercises, open range, ranching, recreation, and small areas of agriculture. A small portion of the study area is used for residential, commercial, and industrial purposes. Except for some small watersheds in the developed areas of the study area, this level of development has minimal effect on peak runoff rates in the area.

5.4 VEGETATION

Vegetation in the lower elevations of the southwestern watersheds consists primarily of sparsely spaced Sonora-Mojave area creosote-bush and bursage desert scrub. The remaining low elevation watersheds of the CRC consist of sparsely spaced big sagebrush shrubland and salt desert scrub. The transition area to the higher watershed elevations is vegetated with sparsely spaced piñon-juniper and mountain sagebrush with more densely spaced ground cover. The highest elevation watersheds are vegetated with more dense ponderosa pine and piñon juniper. There are small pocket areas in the watersheds which are vegetated with pasture type grasses. The overall scarcity of good vegetative cover is consistent with the poor soils in the area and lack of vegetation sustaining precipitation.

5.5 CRC WATERSHED HYDROLOGY AND DESCRIPTIONS

5.5.1 CRC Watershed Hydrology

The Great Basin, a hydrographic basin in which no surface water leaves except by evaporation and which includes much of Nevada, is part of the Basin and Range Physiographic Province (Stewart, 1980). All but the eastern end of the CRC watersheds are within the Great Basin. Similarity of the physical environment throughout the region allows general discussion of surface water of the Caliente Corridor. This general discussion of all the areas is referred to simply as "the region."

Consistent with the Great Basin, hydrographic basins of the region have internal drainage controlled by topography. Almost all streams in the region are ephemeral. Runoff results from snowmelt and from precipitation during storms that occur most commonly in winter and occasionally in fall and spring, and during localized thunderstorms that occur primarily in the summer (DOE, 1988). Much of the runoff quickly infiltrates into rock fractures or into the dry soils, some is carried down alluvial fans in arroyos, and some drains onto dry lake beds where it may stand for weeks as a lake (DOE, 1986). These dry lake beds exhibit a perennial water deficit that has characterized Nevada, at least in historic times (French et al., 1984).

Floods on alluvial fans and dry lake beds in the region will have an impact on portions of the drainage design of the Caliente Rail route. The discussion below gives definitions and mechanisms for these events. The potential exists for sheet flow and channelized flow through arroyos to cause localized flooding throughout the Caliente Corridor. There are some hydrologic studies (see Section 3.1) for portions of the area within the CRC, which delineate floodplains and provide runoff estimates. However, because of the size of the Caliente Corridor, no regionwide comprehensive floodplain analysis has been conducted to delineate the 100- and 500-yr floodplains for all the drainages in the area. A rise in the surface elevation of any standing water on a dry lake bed creates a potential flood hazard where the CRC is located adjacent to dry lake beds. Dry lake beds in Sarcobatus Flat, Alkali Spring Valley, Ralston Valley (Mud Lake), Railroad Valley (South), Penoyer Valley, Coal Valley, and Dry Lake Valley along the rail route from Yucca Mountain to Caliente, collect and dissipate runoff from their respective hydrographic basins.

Many washes and arroyos pose a potential flood hazard to the proposed rail route. In the northeast and southeast, Eagle Valley Reservoir and Pine Canyon Reservoir are the major surface water impoundments. In the eastern portion of the region, Meadow Valley Wash through Rainbow Canyon drains the eastern hydrographic areas to the south and southeast. In the central eastern part of the region, the White River drains the White River Valley and Pahroc Valley to the north and northeast. Several small and shallow reservoirs are located in the central part of the basin. Near Yucca Mountain, Fortymile Canyon originates on Pahute Mesa and intersects the Amargosa arroyo in the Amargosa Desert. The Amargosa arroyo continues to Death Valley, California (ERDA, 1977).

A typical example of the CRC watershed hydrology can be represented by the conditions observed in the southern part of the CRC near Yucca Mountain. In this location, the Amargosa River system drains Yucca Mountain and the surrounding areas. Although referred to as a river, the Amargosa and its tributaries (the washes that drain to it) are dry along most of their lengths most of the time. Exceptions include short stretches where groundwater discharges to or converges with the channel; examples are near Beatty, Nevada; south of Tecopa, California; and in southern Death Valley, California.

No perennial streams or natural bodies of water occur at the Yucca Mountain site or in the surrounding land area. In this region, most of the water from summer storms is lost relatively quickly to evapotranspiration unless a storm is intense enough to produce runoff or subsequent storms occur before the water is lost (CRWMS M&O, 2000). Evapotranspiration is lower during the winter, when water from precipitation or melting snow has a better chance to result in stream flow.

Thunderstorms in the area can be local and intense, creating runoff in one wash while an adjacent wash receives little or no rain. In rare cases, however, storm and runoff conditions can be extensive enough to result in flow being present throughout the drainage systems. Glancy and Beck (1998, all) documented conditions during March 1995 and February 1998 where Fortymile Wash and the Amargosa River flowed simultaneously through their primary channels to Death Valley. The 1995 event represented the first documented case of this flow condition. The 1995 event involved the higher recorded flows. The peak flow near the location where the existing Yucca Mountain access road crosses Fortymile Wash was reported as about 3,500 cubic ft per second (Glancy and Beck 1998, p. 7). This flow is much less than that calculated as the *100-yr flood* event for Fortymile Wash (as discussed in the next paragraph). The occurrence of flow throughout the drainage, however, might be a more unusual event because it would require the generation of runoff over a much larger area than the Fortymile Wash drainage, and in the same timeframe.

Although flow in most washes is rare, the area is subject to flash flooding from intense summer thunderstorms or sustained winter precipitation. When it occurs, intense flooding can include mud and debris flows in addition to water runoff (Blanton 1992).

Table 5-1
Estimated Peak Discharge along Washes at Yucca Mountain[a]

Name	Drainage area (sq mi)	Peak discharge 100-yr flood (cubic ft per second)	Peak discharge 500-yr flood (cubic ft per second)	Regional Maximum flood (cubic ft per second)
Fortymile Wash	313	12000	56800	530,000
Busted Butte (Dune) Wash	6.6	1400	6400	42,000
Drill Hole Wash	15	2300	9900	85,000
Yucca Wash	17	2400	12000	92,000

a. Source: Squires & Young (1984. p. 2) converted to U.S. customary units.

b. Includes Midway Valley and South Portal Washes as tributaries. North and South portal areas.

Table 5-1 lists peak discharges for estimated floods along the main washes at Yucca Mountain, including a value for the estimated regional maximum flood. In addition to the flood estimates listed in the table, DOE used another estimating method, the *probable maximum flood* methodology [based on American National Standards Institute and American Nuclear Society Standards for Nuclear Facilities (ANS 1992, all)] to generate another maximum flood value for washes adjacent to the existing facilities and operations at the North and South Portals. The flood value this method generates, which includes a bulking factor to account for mud and debris (including boulder-size materials), is the most severe reasonably possible for the location under evaluation and is larger than the regional maximum flood listed in Table 5-1. DOE used the probable maximum flood values to predict the areal extent of flooding and to determine if facilities and operations are at risk of flood damage

The U.S. Geological Survey published a methodology for calculating peak flood discharges in the southwestern United States (USGS 1994 & 1997). A preliminary evaluation indicates that the methodology could result in estimates for 100-yr floods that are larger than those listed in Table 5-1.

Potential hydrologic hazards along the rail corridors include flash floods and debris flow. All corridors have the potential flash flooding concerns.

Some flood zones along the potential rail corridors and their associated alternate segments have been identified through the use of Flood Insurance Rate Maps and Floodway Maps published by FEMA . Although limited in coverage, where available, the maps do provide an indication of 100-yr flood zones that might exist in the rail corridors.

5.5.2 CRC Watershed Descriptions

The Caliente Watershed Corridor crosses four (4) Hydrographic Regions (Region 10: Central; Region 12: Escalante Desert; Region 13: Colorado River Basin; and Region 14: Death Valley Basin). The entire tributary watershed area which will affect the rail route drainage design (with current alternative routes) is approximately 10420 sq mi in size. This tributary watershed area can be divided into 9 main watersheds (Table 5-2 and Figure 1-1) and several sub watersheds as referenced in Table 5-3. Each of the sub- watersheds can be treated as separate modeling units. The watersheds are also cross-referenced by rail segment in Table 5-4. The following presents a description of the watershed areas for each of the rail segments. It must be noted that the drainage areas for all the rail segments are not additive, because some of the alternative segments share the same portions of their drainage areas.

Table 5-2
CRC Watersheds

Watershed Name	Approximate Drainage Area To CRC (sq mi)
Upper Amargosa	450
Catus-Sarcobatus Flats	910
Ralston-Stone Cabin Valleys	1990
Hot Creek-Railroad Valleys	2110
Sand Spring-Tikaboo Valleys	1040
White River	1850
Dry Lake Valley	710
Meadow Valley Wash	1340
Escalante Desert	20
Total	**10420**

Table 5-3
Subwatersheds along the Caliente Rail Corridor
By Watershed Name

Main Watershed	Subwatershed Area
Upper Amargosa	Basin 227A –Jackass Flats
Upper Amargosa	Basin 229 – Crater Flat
Upper Amargosa	Basin 228 – Oasis Valley
Catus – Sarcobutus Flats	Basins 144 & 146 – Lida Valley and Sarcobatus Flat
Catus – Sarcobutus Flats	Basin 145 – Stonewall Flat
Catus – Sarcobutus Flats	Basin 142 – Alkali Spring Valley
Ralston – Stone Cabin Valleys	Basins 141 & 149 – Ralston Valley and Stone Cabin Valley
Hot Creek – Railroad Valleys	Basins 156 & 173B – Hot Creek and Railroad Valley (North)
Hot Creek – Railroad Valleys	Basin 173 A – Railroad Valley (South)
Sand Spring – Tikaboo Valleys	Basin 170 – Penoyer Valley (Sand Spring Valley)
Sand Spring – Tikaboo Valleys	Basins 171 & 172 – Coal Valley and Garden Valley
White River	Basins 207 & 208 – White River Valley and Pahroc Valley
Dry Lake Valley	Basin 181 – Dry Lake Valley
Meadow Valley Wash	Basins 198 through 204 – Dry Valley, Rose Valley, Eagle Valley, Spring Valley, Patterson Valley, Panaca Valley, and Clover Valley
Escalante Desert	Basin 197 – Escalante Desert

Table 5-4
Drainage System along the Caliente Rail Corridor by Rail Segment

Rail Segment	Watershed Number	Approximate Number of Arroyo & Wash Crossings	Approximate Rail Section Length (km)
Crestline	197 through 203	35	37
Eccles	203, 204	29	17
Caliente/Eccles	203	2	1
Caliente	203, 204	6	16
CS1 (WS1 included)	208, 181, 203	(WS1: 5) 83	(WS1: 4) 78
WR1/WR3	171, 207, 208	62	34
WR2/WR4	171, 208	41	26
WR2	171	2	7
WR3	171	4	6
WR4	171	2	9
WR1	171	3	2
WR1/WR2	171	9	4
GV1	171, 172	29	26
GV2	171, 172	29	27
GV3	171, 172	39	30
GV4	171, 172	(57 east, 32 west) 89	(35 east, 29 west) 64
CS2	170, 172, 173A	44	33
SR4	156, 170, 173B	58	78
SR2/SR3	156, 173A	(12 east, 71 west) 83	(22 east, 39 west) 61
SR2	173A	13	12
SR3	173A	15	14
CS3	141, 149, 156	84	79
GF1/GF5 (South)	145	1	2
GF1	145	5	10
GF4	141, 142, 144, 145	52	46
GF1/GF5 (North)	141, 142, 145	23	24
GF5	145	9	8
CS4	144, 145	15	20
BC2	144, 146	34	21
BC3	144, 146	24	20
CS5	146, 228	88	34
OV1	228	25	13
OV3	228	33	17
CS6	228	20	7
BW1	228, 229	6	5
BW3	228, 229	8	4
CS7	229, 227A	51	37

Note: Arroyo and wash crossings mostly from 1:24000 quad indicated flow lines. Also included are locations where significant crossings are probable based on prominent flow path contours or aqueducts.

Segment Crestline

The total watershed area upstream of this rail segment is approximately 1092 sq mi with elevations ranging from approximately 4640 ft to approximately 9395 ft, consisting of the entire drainage area of Hydrographic Areas 198 through 202, a portion of Hydrographic Area 203 and a portion of Hydrographic Area 197.

There are about 35 significant arroyo/wash crossings along this rail segment. The first two miles of the rail segment parallel Sheep Spring Wash. The current alignment appears to fall within the wash. The location creates several wash crossings and would subject the railroad to the effects of flooding within the wash. The rail segment continues west crossing many streams at approximately right angles until just west of Miller's Flat where it parallels and twice crosses the wash from Miller's Flat within approximately 1150 ft. It then crosses Miller Spring Wash at an oblique angle. Continuing west the rail segment crosses the east branch of Miser Gulch and then parallels the north branch closely for 1300 ft. The rail segment heads down the west side of Little Mountain crossing several washes and paralleling one wash for approximately 4300 ft with several crossings. The rail segment then parallels the Big Hogback Ridge crossing several washes on its way to paralleling and crossing several times a tributary of Meadow Valley Wash for 9500 ft. The rail segment ends just after crossing Meadow Valley Wash, a major wash for the segment.

Runoff directions, except in Hydrographic Area 197, are primarily toward Meadow Valley Wash which generally flows in a south-southwest direction. Runoff exits the drainage area to the south-southwest. Runoff from Hydrographic Areas 198 through 202 flows into Hydrographic Area 203 (Panaca Valley) through Meadow Valley Wash. A large bridge structure will be necessary for the Meadow Valley Wash crossing. Runoff directions in Hydrographic Area 197 are primarily north or south to Speep Spring Draw which runs east. Runoff exits the drainage area in Sheep Spring Draw, which then flows to the northeast.

Segment Eccles

Total drainage area upstream of this rail segment is approximately 376 sq mi with elevations ranging from approximately 4640 ft to approximately 7600 ft, consisting of a portion of Hydrographic Area 203 and a portion of Hydrographic Area 204.

There are 29 significant arroyo/wash crossings along this rail segment. The rail segment follows Clover Creek across Dutch Flat west for approximately 5600 ft. Clover Creek is a broad wash with multiple channels. It then crosses a possible alluvial fan (braided stream) approximately 650 ft wide on its way west from Dutch Flat Wash. The rail segment then goes up to the ridgeline, closely paralleling and crossing a wash for approximately 6600 ft. On the way down from the ridge the rail segment crosses many washes. The rail segment then reaches a possible alluvial fan from the Miller Bench. The fan crossing is approximately 1600 ft in length and has two narrow debris flow locations indicated on the USGS quadrangle. The rail segment then heads north for three miles to its junction with the Caliente segment, crossing several tributaries of the Meadow Valley Wash.

Runoff directions are primarily west and southwest toward Meadow Valley Wash, which exits the drainage area to the south-southwest. It is unlikely that down stream backwater will affect this rail segment.

Segment Caliente/Eccles

The total watershed area upstream of this rail segment is approximately 1092 sq mi with elevations ranging from approximately 4640 ft to approximately 9395 ft, consisting of the entire drainage area of Hydrographic Areas 198 through 202 and a portion of Hydrographic Area 203.

There are two significant arroyo/wash crossings along this rail segment.

Runoff directions are primarily toward Meadow Valley Wash which exits the drainage area to the south and southeast. Runoff from Hydrographic Areas 198 through 202 flows into Hydrographic Area 203 (Panaca Valley) through Meadow Valley Wash.

Segment Caliente

The total watershed area upstream of this rail segment is approximately 1620 sq mi with elevations ranging from approximately 4400 ft to approximately 9395 ft, consisting of the entire drainage area of Hydrographic Areas 198 through 204.

There are about six significant arroyo/wash crossings along this rail segment. The current location would also subject the rail segment to the flooding effects of Meadow Valley Wash along most of its length. The rail segment closely parallels Meadow Valley Wash for most of its 10 mile length and crosses the major water course several times at oblique angles. The rail segment also crosses several tributaries.

Runoff directions are primarily toward Meadow Valley Wash which exits the drainage area to the south and southeast. Runoff from Hydrographic Areas 198 through 202 flows into Hydrographic Area 203 (Panaca Valley) through Meadow Valley Wash. Runoff from Hydrographic Area 204 joins Meadow Valley Wash at Caliente. The rail segment elevations will be significantly governed by the peak flow elevations in Meadow Valley Wash.

Segment CS1

The total watershed area upstream of the rail segment and tributary area which contributes to flood water volume is approximately 2712 sq mi with elevations ranging from approximately 4590 ft to approximately 11510 ft, consisting of the entire drainage area of Hydrographic Areas 207 and 181, a portion of Hydrographic Area 208 and a portion of Hydrographic Area 203.

There are about 83 significant arroyo/wash crossings along the route in this drainage system. The rail segment starts off with a major crossing at Bennett Springs Wash. It then climbs to Bennett Pass in the Chief Range while crossing many significant washes. Descending from the pass the rail segment crosses many significant washes before reaching Black Canyon where it closely parallels the wash for approximately 2000 ft. The rail segment then crosses several tributaries to Dog Hollow Wash, closely paralleling one tributary for approximately 7900 ft before reaching Dog Hollow Wash. The rail segment closely parallels Dog Hollow Wash to the wash terminus, perhaps at an alluvial fan. The rail segment continues west crossing a cluster of Coyote Wash tributaries approximately 13500 ft north of a dry lake bed. Coyote Wash is a major wash. The rail segment then crosses the remainder of the Dry Lake Valley and starts up the west side of the valley, closely paralleling a wash for approximately 3300 ft. The Dry Lake Valley is approximately 1 mile across. The flat slope of the valley floor will probably necessitate elevating the rail segment for most of the crossing. The nearest dry lake bed is only 10 ft below the ground elevation of the rail segment. The rail segment then continues west, gradually climbing around the north end of the North Pahroc Range and crossing many significant washes enroute. The rail segment then bends north crossing many significant washes which are tributaries to the White River until it is closely paralleling the river. It parallels the river for approximately 10 miles before crossing the river at an oblique angle. The White River stream bed is approximately 2050 ft wide at the crossing point. However, the angle of the crossing increases the length needing elevation to at least 5250 ft. Once across the White River, the rail segment continues up the far side for approximately 8200' crossing several significant washes before reaching the WR rail segments.

Runoff directions in Hydrographic Areas 207 and 208 are primarily toward the White River which flow out of the area to the south and southeast. Runoff from Hydrographic Area 207 (White River Valley) flows into Hydrographic Area 208 (Pahroc Valley) to White River. The rail route elevation design for the rail section crossing the White River channel will be governed by the peak runoff level in the White River. Runoff directions in Hydrographic Area 181 are primarily toward Dry Lake depression at the south central portion of the hydrographic area just south of this rail segment. Runoff from the drainage area in Hydrographic Area 181 flows to the Dry Lake Valley depression in the south central area of this closed hydrographic area. The peak water level at Dry Lake depression will need to be determined for the rail route elevation and alignment design for this rail segment along the edge of the Dry Lake depression.

Segment WR1/WR3

The total watershed area upstream of this rail segment is approximately 79 sq mi with elevations ranging from approximately 5010 ft to approximately 8440 ft, consisting of a portion of Hydrographic Area 171, a portion of Hydrographic Area 207 and a portion of Hydrographic Area 208.

There are about 62 significant arroyo/wash crossings along this segment. The rail segment starts just west of the White River and heads north and west around the north end of the Seaman Range keeping to the lower slopes of the range. The rail segment crosses numerous significant washes while paralleling the mountains. The rail segment then continues southwest into Coal Valley crossing several washes on the way. The termination of many washes on the slopes above Coal Valley suggests that alluvial sediment is common along this portion of the rail segment.

Runoff directions are primarily south, southeast and northeast toward White River which flow out of the area to the south and southeast. Runoff from Hydrographic Area 207 (White River Valley) flows into Hydrographic Area 208 (Pahroc Valley) to White River.

Segment WR2/WR4

The total watershed area upstream of this rail segment is approximately 26 sq mi with elevations ranging from approximately 5160 ft to approximately 8590 ft, consisting of a portion of Hydrographic Area 171 and a portion of Hydrographic Area 208.

There are about 41 significant arroyo/wash crossings along this segment. The rail segment starts just west of the White River and heads west through the Seaman Range via Timber Pass. The rail segment crosses numerous significant washes while paralleling the mountains. It then closely parallels a wash for approximately 8200 ft before reaching the summit of the pass. The rail segment then continues down into Coal Valley crossing numerous washes on its way down the west side of the Seaman Range before terminating on the west side of Coal Valley.

Runoff directions in Hydrographic Area 171 are primarily southwest. Runoff exits the drainage area in Hydrographic Area 171 to the depression area southwest of this rail segment in this closed drainage system. Runoff directions in Hydrographic Area 208 are primarily northeast. Runoff exits the drainage area in Hydrographic Area 208 to White River east of this rail segment.

Segment WR2

The total watershed area upstream of this rail segment is approximately 48 sq mi with elevations ranging from approximately 5010 ft to approximately 7160 ft, consisting of a portion of Hydrographic Area 171.

There are two significant arroyo/wash crossings along this segment. The rail segment crosses Coal Valley and the main wash from the north. The relatively flat slopes in the valley indicate the west 11800 ± ft of the rail segment may need to be elevated above the valley floor.

Runoff directions are primarily south and southeast. Runoff exits the drainage area to the depression area south of this rail segment in this closed drainage system.

Segment WR3

The total watershed area upstream of this rail segment is approximately 12 sq mi with elevations ranging from approximately 5005 ft to approximately 7160 ft, consisting of a portion of Hydrographic Area 171.

There are four significant arroyo/wash crossings along this segment. The rail segment parallels the Golden Gate Range along the west side of Coal Valley. It is in the alluvial deposition area of several significant washes flowing out of the Golden Gate Range.

Runoff directions are primarily southeast. Runoff exits the drainage area to the depression area southeast of this rail segment in this closed drainage system.

Segment WR4

The total watershed area upstream of this rail segment is approximately 61 sq mi with elevations ranging from approximately 5005 ft to approximately 7160 ft, consisting of a portion of Hydrographic Area 171.

There are two significant arroyo/wash crossings along this segment. The rail segment crosses Coal Valley towards the southwest. The relatively flat slopes in the valley indicate the west 21000 ± ft of the rail segment may need to be elevated above the valley floor.

Runoff directions are primarily south, southeast and southwest. Runoff exits the drainage area to the depression area southeast of this rail segment in this closed drainage system.

Segment WR1

Total drainage area upstream of this rail segment is approximately two sq mi with elevations ranging from approximately 5010 ft to approximately 7160 ft, consisting of a portion of Hydrographic Area 171.

The rail segment parallels the Golden Gate Range along the west side of Coal Valley. It crosses three significant washes flowing out of the Golden Gate Range and is in the alluvial deposition area of all three washes.

Runoff direction is primarily southeast. Runoff exits the drainage area to the depression area south of this rail segment in this closed drainage system. It is unlikely that down stream backwater will affect the rail route.

Segment WR1/WR2

Total drainage area upstream of this rail segment is approximately four sq mi with elevations ranging from approximately 5010 ft to approximately 7160 ft, consisting of a portion of Hydrographic Area 171.

There are nine significant arroyo/wash crossings along this segment. The rail segment rises from the west side of Coal Valley towards a pass in the Golden Gate Range. It crosses several significant washes flowing out of the Golden Gate Range and is in the alluvial deposition area of several significant washes. The rail segment then closely parallels a significant wash for the last 5250 ft.

Runoff directions are primarily south and southeast. Runoff exits the drainage area to the depression area south of this rail segment in this closed drainage system. It is unlikely that down stream backwater will affect the rail route.

Segment GV1

The total watershed area upstream of this rail segment is approximately 316 sq mi with elevations ranging from approximately 5160 ft to approximately 11300 ft, consisting of a portion of Hydrographic Area 172 and a small portion of Hydrographic Area 171.

There are about 29 significant arroyo/wash crossings along this segment. The rail segment traverses Garden Valley from the Golden Gate Range to the north end of the Worthington Mountains crossing many significant washes. As the rail segment traverses Garden Valley to the southwest it crosses many significant and several major washes. Cherry Creek forms a classic alluvial fan on the northwest side of the rail segment as it flows into Garden Valley. The alluvial fan is approximately 10200 ft wide at the point the rail segment crosses the fan. It is suspected that other washes tributary to Cherry Creek may also have deposited alluvial debris which could negatively impact the design of this rail segment.

Runoff from Hydrographic Area 172 (Garden Valley) flows into Hydrographic Area 171 (Coal Valley) through Water Gap to the depression area of this closed drainage system. Runoff from Hydrographic Area 171 (Coal Valley) exits the drainage area to flow east from the north Golden Gate Range pass to the depression area of this closed drainage system.

Segment GV2

The total watershed area upstream of this rail segment is approximately 501 sq mi with elevations ranging from approximately 5100 ft to approximately 11300 ft, consisting of a portion of Hydrographic Area 172 and a portion of Hydrographic Area 171.

There are about 29 significant arroyo/wash crossings along this segment. The rail segment starts on the east side of the Golden Gate Range and heads southwest through Water Gap across several significant washes. As the rail segment passes through Water Gap it crosses Cherry Creek, a major wash, at an oblique angle for about 3600 ft. Cherry Creek forms an alluvial fan on the east side of the Golden Gate Range which may create significant design problems for the rail segment. The rail segment traverses Garden Valley from the Golden Gate Range to the north end of the Worthington Mountains crossing many significant washes. As the rail segment approaches the Worthington Mountains it closely parallels and crosses a significant wash for approximately 14100 ft.

Runoff from Hydrographic Area 172 (Garden Valley) flows into Hydrographic Area 171 (Coal Valley) through Water Gap to the depression area of this closed drainage system. Runoff from Hydrographic Area 171 (Coal Valley) flows east through Water Gap to the depression area of this closed drainage system.

Segment GV3

The total watershed area upstream of this rail segment is approximately 289 sq mi with elevations ranging from approximately 5180 ft to approximately 11300 ft, consisting of a portion of Hydrographic Area 172 and a small portion of Hydrographic Area 171.

There are about 39 significant arroyo/wash crossings along this segment. The rail segment starts in the Golden Gate Range and heads west through a pass. The rail segment closely parallels a significant wash for the first 2000 ft. As the rail segment passes through the pass it crosses several significant washes. As the rail segment traverses Garden Valley southwest from the Golden Gate Range to the north end of the Worthington Mountains it crosses many significant and several major washes. Cherry Creek forms a classic alluvial fan on the northwest side of the rail segment as it flows into Garden Valley. The alluvial fan is approximately 7500 ft wide at the point the rail segment crosses the fan. It is suspected that other washes tributary to Cherry Creek may also have deposited alluvial debris which could negatively impact the design of the rail segment.

Runoff from Hydrographic Area 172 (Garden Valley) flows into Hydrographic Area 171 (Coal Valley) through Water Gap to the depression area of this closed drainage system. Runoff from Hydrographic Area 171 (Coal Valley) exits the drainage area to flow east from the north Golden Gate Range pass to the depression area of this closed drainage system.

Segment GV4

The total watershed area upstream of this rail segment is approximately 140 sq mi with elevations ranging from approximately 5000 ft to approximately 8970 ft, consisting of a portion of Hydrographic Area 171 and a portion of Hydrographic Area 172.

There are about 83 significant arroyo/wash crossings along this segment. The rail segment starts on the east side of the Golden Gate Range, north of Water Gap, and heads south past Water Gap along the eastern base of the Golden Gate Range. As the rail segment passes across Water Gap it crosses Cherry Creek, a major wash, and its alluvial fan for approximately 6200 ft. The Cherry Creek alluvial fan on the east side of the Golden Gate Range may create significant design problems for the rail segment. As the rail segment heads south it crosses numerous washes flowing out of the Golden Gate Range. Aerial photographs show that most of the washes have formed alluvial fans where they meet the flatter slopes associated with Coal Valley. These alluvial fans may adversely impact the design of this rail segment. Just north of Murphy Gap the rail segment closely parallels a significant wash for approximately 8500 ft. As the rail segment passes through Murphy Gap the rail segment closely parallels Cold Springs Wash, a major feature, for approximately 4900 ft. Once the rail segment enters Wild Horse Valley it closely parallels a western tributary of Cold Springs Wash for approximately 13500 ft as it heads west and then north. As the rail segment approaches the saddle to Garden Valley it crosses several significant washes. From the saddle the rail segment descends north toward Garden Valley closely paralleling and crossing a significant wash for approximately 13800 ft. The rail segment then bends west and closely parallels and crosses another significant wash for approximately 9800 ft. The rail segment then heads north into Garden Valley crossing many significant washes, some multiple times, before ending at the north end of the Worthington Mountains. Aerial photographs show that most of the washes have formed alluvial fans where they meet the flatter slopes associated with Garden Valley.

Runoff from Hydrographic Area 172 (Garden Valley) flows into Hydrographic Area 171 (Coal Valley) through Water Gap to the depression area of this closed drainage system.

Segment CS2

The total watershed area upstream of this rail segment is approximately 96 sq mi with elevations ranging from approximately 5490 ft to approximately 9200 ft, consisting of a portion of Hydrographic Area 170, a portion of Hydrographic Area 172, and a portion of Hydrographic Area 173A.

There are about 44 significant arroyo/wash crossings along this segment. The rail segment starts at the north end of the Worthington Mountains in Garden Valley. As the rail segment heads west toward Sand Spring Valley it closely parallels a significant wash for approximately 7900 ft. After crossing the saddle to Sand Spring Valley the rail segment closely parallels a significant wash for approximately 2000 ft. The rail segment then heads west, crossing many significant washes which flow south from the Quinn Canyon Range. Just before terminating near the saddle to Railroad Valley, the rail segment closely parallels a significant wash for approximately 2300 ft.

Runoff directions are primarily southeast and southwest. Runoff in Hydrographic Area 170 exits the watershed area southeasterly and southward to the Sand Spring Valley dry lake bed in the central area of this closed hydrographic area.

Segment SR4

The total watershed area upstream of this rail segment is approximately 276 sq mi with elevations ranging from approximately 4910 ft to approximately 7990 ft, consisting of portions of Hydrographic Area 156, Hydrographic Area 173B, and Hydrographic Area 170.

This segment crosses about 58 significant washes. Most of these crossings are at nearly right angles and at least 20 of them are major crossings with relatively large tributary drainage areas. A portion of this segment, approximately 1300 ft long, is almost parallel to one of the major wash paths.

Runoff directions in Hydrographic Area 156 (Hot Creek Valley) are primarily north, east, and northeast. Runoff in Hydrographic Area 156 exits the drainage area to a section of Reveille Valley, which then drains northeast around the Reveille Range, then southeasterly through Echo Canyon toward Hydrographic Area 173B (Railroad Valley, North Part). Runoff in Hydrographic Area 170 exits the drainage area south to a wash running easterly then southeast to Sand Spring Valley.

Segment SR2/SR3 (East)

The total watershed area upstream of this rail segment is approximately 99 sq mi with elevations ranging from approximately 5360 ft to approximately 7080 ft, consisting of portions of Hydrographic Area 173A.

This segment crosses about 12 significant washes. Most of these crossings are at nearly right angles and two of them are major crossings with relatively large tributary drainage areas. A portion of this segment, approximately 4600 ft long, is almost parallel to one of the major wash paths.

Runoff directions are primarily north and northeast. Runoff exits the watershed area northward to Railroad Valley dry lake bed in the north central area of Hydrographic Area 173A (Railroad Valley, South Part).

Segment SR2

The total watershed area upstream of this rail segment is approximately 50 sq mi with elevations ranging from approximately 5640 ft to approximately 8660 ft, consisting of a portion of Hydrographic Area 173A.

This segment crosses about 13 significant washes. Most of these crossings are at nearly right angles and three of them are major crossings with relatively large tributary drainage areas. A portion of this segment, approximately 2000 ft long, is almost parallel to one of the major wash paths. This segment crosses this major wash path back and forth several times. The total tributary area to this segment is slightly larger than that of Segment SR3.

Runoff directions are primarily east and southeast. Runoff in Hydrographic Area 173A (Railroad Valley, South Part) exits the watershed area to a section of Reveille Valley which then drains southeasterly around the Reveille Range, then north to the Railroad Valley dry lake bed in the north central area of Hydrographic Area 173A (Railroad Valley, South Part).

Segment SR3

The total watershed area upstream of this rail segment is approximately 45 sq mi with elevations ranging from approximately 5640 ft to approximately 8660 ft, consisting of a portion of Hydrographic Area 173A.

This segment crosses about 15 significant washes. Most of these crossings are at nearly right angles and three of them are major crossings with relatively large tributary drainage areas. A portion of this segment, approximately 9500 ft long, is almost parallel to one of the major wash paths. Total tributary area to this segment is slightly smaller than that to Segment SR2.

Runoff in Hydrographic Area 173A (Railroad Valley, South Part) exits the watershed area to a section of Reveille Valley which then drains southeasterly around the Reveille Range, then north to the Railroad Valley dry lake bed in the north central area of Hydrographic Area 173A (Railroad Valley, South Part).

Segment SR2/SR3 (West)

The total watershed area upstream of this rail segment is approximately 128 sq mi with elevations ranging from approximately 5760 ft to approximately 9400 ft, consisting of a portion of Hydrographic Area 156 and a portion of Hydrographic Area 173A.

This segment crosses about 71 significant washes. Most of these crossings are at nearly right angles and about 12 of them are major crossings with relatively large tributary drainage areas.

Runoff directions in Hydrographic Area 156 (Hot Creek Valley) are primarily north, east, and northeast. Runoff in Hydrographic Area 156 exits the drainage area to a section of Reveille Valley, which then drains northeast around the Reveille Range, then southeasterly through Echo Canyon toward Hydrographic Area 173B (Railroad Valley, North Part). Runoff in Hydrographic Area 173A (Railroad Valley, South Part) exits the watershed area northeast to a section of Reveille Valley which then drains southeasterly around the Reveille Range, then north to the Railroad Valley dry lake bed in the north central area of Hydrographic Area 173A (Railroad Valley, South Part).

Segment CS3

The total watershed area upstream of this rail segment and the tributary area which contributes to flood water volume is approximately 1966 sq mi with elevations ranging from approximately 5190 ft to approximately 10740 ft, consisting of the entire drainage area of Hydrographic Areas 141 and 149 and a small portion of Hydrographic Area 156.

This segment crosses about 84 significant washes. Most of these crossings are at nearly right angles and about 15 of them are major crossings with relatively large tributary drainage areas. A portion of the segment, approximately 9 miles long, runs near the edge of Mud Lake. This segment also passes through two potential alluvial fans.

Runoff directions are primarily toward Mud Lake at the southwestern portion of Hydrographic Area 141 (Ralston Valley) just southwest of the rail segment. Runoff from Hydrographic Area 149 (Stone Cabin Valley) flows into Hydrographic Area 141 (Ralston Valley) to the depression area of this closed drainage system at Mud Lake. The peak water level at Mud Lake will be determined for the rail route elevation and alignment design for the rail section along the edge of Mud Lake. Runoff from Hydrographic Area 156 (Hot Creek Valley) flows north to the stream below the CRC and then east into Hot Creek Valley. Hydrographic Area 156 then drains southeasterly through Echo Canyon toward Hydrographic Area 173B (Railroad Valley, North Part).

Segment GF1/GF5 (South)

Total drainage area upstream of this rail segment is approximately 5.8 sq mi with elevations ranging from approximately 5050 ft to approximately 6860 ft, consisting of a portion of Hydrographic Area 145.

This segment crosses one major wash. This crossing is at an angle of approximately 45 degrees. Total tributary area to this segment is much smaller than that to Segment GF4.

Runoff directions are primarily east and southeast. Runoff exits the drainage area to the depression area of this closed hydrographic area (145) at Stonewall Flat. It is unlikely that down stream backwater will affect the rail route.

Segment GF1

Total drainage area upstream of this rail segment is approximately 3.3 sq mi with elevations ranging from approximately 5190 ft to approximately 6860 ft, consisting of a portion of Hydrographic Area 145.

This segment crosses 5 significant washes. Most of these crossings are at nearly right angles and two of them are major crossings with relatively large tributary drainage areas. Total tributary area to this segment is much smaller than that to Segment GF5.

Runoff directions are primarily southeast, south and southwest. Runoff exits the drainage area to the depression area of this closed hydrographic area (145) at Stonewall Flat. It is unlikely that down stream backwater will affect the rail route.

Segment GF4

The total watershed area upstream of this rail segment is approximately 79 sq mi with elevations ranging from approximately 5050 ft to approximately 7510 ft, consisting of a portion of Hydrographic Area 141, a portion of Hydrographic Area 142, and a portion of Hydrographic Area 144, and a portion of Hydrographic Area 145.

This segment crosses about 52 significant washes. Most of these crossings are at nearly right angles and about 11 of them are major crossings with relatively large tributary drainage areas. A portion of the segment, approximately 9000 ft long, is almost parallel to one of the major wash paths. This segment crosses this major wash path back and forth several times.

Runoff directions vary in different hydrographic areas. In Hydrographic Area 141, the runoff direction is primarily east and southeast towards Mud Lake. In Hydrographic Area 142, the runoff directions are primarily west to northwest. Runoff exits the watershed area to the depression area of this closed hydrographic area (142) at Alkali Lake. In Hydrographic Area 144, runoff directions are primarily to southeast. In Hydrographic Area 145, runoff directions are primarily towards south and southeast. It is unlikely that down stream backwater will affect the rail route.

Segment GF1/GF5 (North)

Total drainage area upstream of this rail segment is approximately 19 sq mi with elevations ranging from approximately 5260 ft to approximately 6860 ft, consisting of a portion of Hydrographic Area 141, a portion of Hydrographic Area 142, and a portion of Hydrographic Area 145.

This segment crosses 23 significant washes. Most of these crossings are at nearly right angles and seven of them are major crossings with relatively large tributary drainage areas. Total tributary area to this segment is much smaller than that to Segment GF4.

Runoff directions vary in different hydrographic areas. In Hydrographic Area 141, runoff direction is primarily east and southeast towards Mud Lake. In Hydrographic Area 142, runoff directions are primarily west to northwest. Runoff exits the drainage area to the depression area of this closed hydrographic area (142) at Alkali Lake. In Hydrographic Area 145, runoff directions are primarily south, southwest, and southeast. Runoff exits the drainage area to the depression area of this closed hydrographic area (145) at Stonewall Flat. It is unlikely that down stream backwater will affect the rail route.

Segment GF5

Total drainage area upstream of this rail segment is approximately 26 sq mi with elevations ranging from approximately 5190 ft to approximately 6860 ft, consisting of a portion of Hydrographic Area 145.

This segment crosses nine significant washes. Most of these crossings are at nearly right angles and one of them is a major crossing with a relatively large tributary drainage area. A portion of the segment, approximately 2300 ft long, is almost parallel to one of the wash paths. This segment crosses the major wash path back and forth several times.

Runoff directions are primarily east to southeast. Runoff exits the drainage area to the depression area of this closed hydrographic area (145) at Stonewall Flat. It is unlikely that down stream backwater will affect the rail route.

Segment CS4

The total watershed area upstream of this rail segment is approximately 77 sq mi with elevations ranging from approximately 4690 ft to approximately 7880 ft, consisting of a portion of Hydrographic Area 144 and a portion of Hydrographic Area 145.

This segment crosses about15 significant washes. Most of these crossings are at nearly right angles and two of them are major crossings with relatively large tributary drainage areas. A portion of this segment runs near the edge of a small dry lake.

Runoff directions are primarily toward south and southeast. Runoff in Hydrographic Area 145 exits the drainage area to the depression area of this closed hydrographic area at Stonewall Flat. This rail segment passes through the Stonewall Flat in Hydrographic Area 144 and its floodplain. The flood level at this floodplain crossing will need to be determined.

Segment BC2

The total watershed area upstream of this rail segment is approximately 672 sq mi with elevations ranging from approximately 4125 ft to approximately 9040 ft, consisting of the entire drainage area of Hydrographic Area 144 and a portion of Hydrographic Area146.

This segment crosses about 34 significant washes. Most of these crossings are at nearly right angles and four of them are major crossings with relatively large tributary drainage areas. A portion of the segment, approximately 5200 ft long, is almost parallel to one of the wash paths. This segment crosses a major wash path back and forth several times.

Runoff directions are primarily toward the central western portion of Hydrographic Area 146 at Sarcobatus Flat southwest of the rail route segment CS5. Runoff from Hydrographic Area 144 (Lida Valley) flows into Hydrographic Area 146 (Sarcobatus Flat) to the depression area of this closed drainage system at Sarcobatus Flat. It is unlikely that the downstream dry lake bed backwater will affect the rail route.

Segment BC3

The total watershed area upstream of this rail segment is approximately 683 sq mi with elevations ranging from approximately 4125 ft to approximately 9040 ft, consisting of the entire drainage area of Hydrographic Area 144 and a portion of Hydrographic Area146.

This segment crosses about 24 significant washes. Most of these crossings are at nearly right angles and two of them are major crossings with relatively large tributary drainage areas. This segment also crosses a dry lake bed outlet. The total watershed area to this segment is a little larger than that to Segment BC2.

Runoff directions are primarily toward the central western portion of Hydrographic Area 146 at Sarcobatus Flat southwest of the rail route segment CS5. Runoff from Hydrographic Area 144 (Lida Valley) flows into Hydrographic Area 146 (Sarcobatus Flat) to the depression area of this closed drainage system at Sarcobatus Flat. It is unlikely that downstream dry lake bed backwater will affect the rail route.

Segment CS5

The total watershed area upstream of this rail segment is approximately 228 sq mi with elevations ranging from approximately 3990 ft to approximately 6900 ft, consisting of a portion of Hydrographic Area 146 (Sarcobatus Flat) and a small portion of Hydrographic Area 228.

This segment crosses about 88 significant washes. Most of these crossings are at nearly right angles and five of them are major crossings with relatively large tributary drainage areas. A portion of the segment, approximately 7200 ft long, is almost parallel to one of the wash paths. This segment also passes through an apparent alluvial fan with past debris flow and a portion of it transverses near the edge of a small dry lake bed.

Runoff directions are primarily toward a depression in the central western portion of Hydrographic Area 146 at Sarcobatus Flat southwest of the rail route. It is unlikely that downstream dry lake bed backwater will affect the rail route.

Segment OV1

The total watershed area upstream of this rail segment is approximately 279 sq mi with elevations ranging from approximately 3870 ft to approximately 7450 ft, consisting of a portion of Hydrographic Area 228 (Oasis Valley).

This segment crosses about 25 significant washes. Most of these crossings are at nearly right angles and eight of them are major crossings with relatively large tributary drainage areas. The largest crossing is at Thirsty Canyon Wash and its floodplain and it spans approximately 2500 ft over a cluster of wash paths. One of the crossings is almost parallel to one of the wash paths for approximately 1200 ft.

Runoff directions are primarily southwest and southeast. Runoff exits the watershed area through the upper Amargosa River. This rail segment crosses Amargosa River and its floodplain.

Segment OV3

The total watershed area upstream of this rail segment is approximately 267 sq mi with elevations ranging from approximately 3970 ft to approximately 7450 ft, consisting of a portion of Hydrographic Area 228 (Oasis Valley).

This segment crosses about 33 significant washes. Most of these crossings are at nearly right angles and six of them are major crossings with relatively large tributary drainage areas. The largest crossing is at Thirsty Canyon Wash and it spans approximately 1300 ft over a cluster of wash paths.

Runoff directions are primarily southwest and southeast. Runoff exits the watershed area through the upper Amargosa River. This rail segment crosses the Amargosa River and its floodplain.

Segment CS6

The total watershed area upstream of this rail segment is approximately 91 sq mi with elevations ranging from approximately 3840 ft to approximately 7440 ft, consisting of a portion of Hydrographic Area 228 (Oasis Valley).

This segment crosses about 20 significant washes at nearly right angles, and three of the crossings are major ones with relatively large tributary drainage areas. The largest crossing is at Beatty Wash and its floodplain.

Runoff directions are primarily southwest. Runoff exits the watershed area to Oasis Valley then drains southwesterly toward the Amargosa River. This rail segment crosses Beatty Wash and its floodplain.

Segment BW1

The total watershed area upstream of this rail segment is approximately 2 sq mi with elevations ranging from approximately 4030 ft to approximately 4790 ft, consisting of a portion of Hydrographic Area 228 (Oasis Valley) and a portion of Hydrographic Area 229 (Crater Flat).

This segment crosses about eight significant washes at nearly right angles, and two of the crossings are major ones with relatively larger tributary watershed areas. The total tributary area to this segment is slightly larger than that to segment BW3.

Runoff directions are primarily southeast and southwest. Runoff in Hydrographic Area 228 exits the watershed area to the Beatty Wash and then drains westerly toward Amargosa River in Oasis Valley. Runoff in Hydrographic Area 229 exits the watershed area to the lower portion of Crater Flat and then drains southerly towards the Amargosa River in Amargosa Valley.

Segment BW3

The total watershed area upstream of this rail segment is approximately 1 sq mi with elevations ranging from approximately 4020 ft to approximately 4790 ft, consisting of a portion of Hydrographic Area 228 (Oasis Valley) and a portion of Hydrographic Area 229 (Crater Flat).

This segment crosses about eight significant washes at nearly right angles, and two of the crossings are major ones with relatively larger tributary watershed areas.

Runoff directions are primarily southeast and southwest. Runoff in Hydrographic Area 228 exits the watershed area to the Beatty Wash and then drains westerly toward Amargosa River in Oasis Valley. Runoff in Hydrographic Area 229 exits the watershed area to the lower portion of Crater Flat and then drains southerly toward Amargosa River in Amargosa Valley.

Segment CS7

Total drainage area upstream of this rail segment is approximately 79 sq mi with elevations ranging from approximately 3210 ft to approximately 6500 ft, consisting of a portion of Hydrographic Area 229 (Crater Flat) and a portion of Hydrographic Area 227A.

This segment crosses 51 significant washes. Most of these crossings are at nearly right angles and 11 of them are major crossings with relatively large tributary drainage areas. A portion of the segment in Crater Flat, approximately 1600 ft long, is almost parallel to one of the wash paths. Near the end of this segment, a portion of it, approximately 1000 ft long, is almost parallel to the last significant wash path it crosses.

In Hydrographic Area 229, runoff directions are primarily south, southeast, and southwest. Runoff exits the drainage area to the lower portion of Crater Flat and then drains southerly toward Amargosa River in Amargosa Valley. In Hydrographic Area 227A, Runoff directions are primarily toward south and southeast. Runoff exits the drainage area to Fortymile Wash which flows to Amargosa River. It is unlikely that down stream backwater will affect the rail route.

5.6 EXISTING DRAINAGE FACILITIES

Except where existing rail routes are to be utilized no existing drainage facilities are known to exist along the corridor.

5.7 HYDROLOGIC HAZARDS

5.7.1 Floods

The CRC crosses around 352 identifiable washes enroute to the Yucca Mountain site (CRWMS M&O 1998, all). Among these crossings are: Clover Creek, Meadow Valley Wash, White River, unnamed drainage gully in east/central Nye County in the section from Sand Spring Valley to Mud Lake, Mud Lake basin and drainage tributaries, unnamed washes to the north and south of Ralston, Tolicha Wash, Amargosa River, and Beatty Wash. Some crossings are in 100-yr flood zones delineated by studies in areas the corridor passes through. A majority of the crossings may also be subject to threats of flash floods with mud or debris flow.

5.7.2 Alluvial Fans

Several of the areas along the CRC route cross through alluvial fans or cross below the toe of the fan surface. In either case, the risk to the CRC is from both active alluvial fans as well as alluvial surfaces whose braided channels are limited in capacity to less than the 100-yr flood event. In both cases, the direction of runoff across the fan is variable which will require either oversized drainage improvements under the CRC or on-fan improvements to define and confine the 100-yr flow path. In addition, erosion and sediment transport are potential hazards on alluvial fans.

Probable alluvial fan crossings include:

- Hydrographic Area 146
  Segment CS5 crosses the Tolicha Wash fan located northeast of Sarcobatus Flat.

- Hydrographic Area 149
  Segment CS3 crosses the Haws Canyon Fan and the Bellehelen Canyon Fan located in the southeastern portion of Stone Cabin Valley.

- Hydrographic Area 172
  Segments GV1 and GV3 cross the Cottonwood Creek-Pine Creek Fan located in the northwestern portion of Garden Valley.

- Hydrographic Area 171
  Segment WR3 crosses the Golden Gate Range Fan located in the northwestern portion of Coal Valley.

Segments GV2 and GV4 cross the Water Gap-Cherry Creek Fan located in the northwestern portion of Coal Valley.

Additional alluvial fans areas may be identified during the detailed hydrologic modeling phase of this project.

5.7.3 Mud and Debris Flows

Mud and debris flow risks exist throughout the CRC where existing flow path slopes are sufficiently steep to support the displacement and transport of mud and debris down the flow path through the CRC. This risk is minimized in locations where the CRC is located at a distance greater than the expected runout location of the mud and debris flow. The actual risk from mud and debris flow can only be determined by on-site hydrologic analysis and geotechnical analysis. Identifications will be completed with the hydrologic modeling phase of this project.

5.7.4 Dry Lake Beds

Several of the watershed areas are closed basins and as such, runoff from the arroyos and washes end up in dry lake beds. Other areas also have dry lake beds which, when filled, have outflow points. Dry lake beds, in closed basins or not, are a concern when the 100-yr flood stage of the lake may cause inundation of the railroad, its embankment, or saturation of the underlying soils. Additionally, fine silts will be prevalent in the soils of a dry lake bed. As a minimum, the CRC should be located such that the railroad may be routed around the area affected by lake flooding.

The current suspected potential areas are identified in the description of the specific rail segments in Section 5.5.2.

5.7.5 Reservoirs

There are several reservoirs located within the CRC watersheds. These include Eagle Valley Reservoir, Pine Canyon Reservoir, and the series of reservoirs on the White River (Dacey, Adams McGill, Cold Springs, Hay Meadow, Tule Field, and Whipple reservoirs). These reservoirs can create additional hydrologic hazards to the CRC if they breach during a flood event. The extent of the hazard to the CRC is dependent on the increase in peak flow caused by the breach at the CRC and upon the hazard design of the individual reservoirs. Some of the reservoirs may reduce flood hazards to the CRC if they are designed and maintained to provide flood control benefits. A complete listing of the dams in the watershed is available on the following website: http://water.nv.gov/IS/Dams/Dam_Queries.htm.

5.7.6 Erosion and Sedimentations

Erosion and sedimentation in the natural channel becomes a hydrologic hazard in two instances. Both may occur in situations where the stream passes near or parallels the railroad. First, erosion and sedimentation is a hazard where the water surface of a flood event is increased over that surface computed based upon a fixed-bed assumption. Second, erosion of channel banks caused by flood events can undermine the railroad bed and facilities. Additionally, sediment loading affects the erosion capabilities of the stream, both in terms of ability to erode solid masses and pick up additional sediment from banks and bed. The extent of this potential problem will depend on the bank and bed materials, the velocity of the flood flow at specific locations, and the location of the CRC related to these features. Once the peak flood flows and velocities are determined, the risk to the CRC from erosion and sedimentation problems can be identified. Erosion and sedimentation considerations at structures will be addressed as part of the design process for each individual structure.

6.0 HYDROLOGICAL FIELD RECONNAISSANCE

6.1 INTRODUCTION

In order to accurately model the conditions that are present along the CRC , field reconnaissance was utilized to collect site data. Starting on January 19^{th}, 2005, multiple crews consisting of two individuals drove and hiked the CRC Alignment from the town of Caliente to Yucca Mountain, for a total of approximately 530 linear miles. Additionally, the crews surveyed the entire watershed that contributed to the alignment, which consisted of approximately 10,000 sq mi. Field work was completed by the middle of May, with the entire green map surveyed.

6.1.1 Purpose

Due to the size and variety of the area that is to be modeled, detailed information was needed to form an accurate and reliable model. Existing information such as USGS maps and Aerial photographs are not precise enough to use on their own. It was necessary to perform field investigations to determine the physical characteristics of the area being modeled as well as determine any areas of special significance. Data collected included hydrologic and hydraulic information, land use, land cover, and soil type. Areas of special interest include rivers, full running washes, reservoirs and dry lakes.

6.1.2 Crews

Each crew member attended thorough training in safety procedures, defensive driving and equipment use. The training lasted approximately three days and covered everything from CPR to the use of a handheld Global Positioning System (GPS). Field crews consisted of two individuals to each vehicle, with as many as three sets of crews out in the field at all times. Crew members stayed in small towns along the alignment in order to expedite the data collection. According to safety regulations, crews checked in every four hours with Ranch Control (BSC) or the Nevada Point of Contact to inform everyone of their location. This was used to ensure short response time in the case of any emergencies. Grid Map locations or GPS position were provided to determine the general location of the work taking place.

6.1.3 Methods

Utilizing tablet pc's with a GPS receiver attached, along with a digital camera that also contained a GPS receiver, data was collected in real time conditions. Data was collected with a series of methods within the tablet pc. Geographic Information System (GIS) maps containing topography, watershed basins, and soil boundaries along with roads, wilderness areas and national parks were loaded onto the tablet pc. Using the GPS capabilities of the tablet pc, data such as wash points and soil types were collected and placed on the maps at exact locations. Each data point was collected with a GPS stamp showing the location of the collector at the time the information was gathered. Additionally, each data point was accompanied by photographs of the surrounding area. These photographs were also stamped with GPS coordinates. This allowed for the photographs to be hyper-linked directly to the GIS maps for later review.

6.2 DATA

6.2.1 Hydrologic Data

Watershed boundaries were roughly determined using a watershed delineation program that defined the basin boundaries for the area. The basin boundaries were then confirmed in the field for accuracy using the tablet pc. Confirmed basins can be used directly in the model while basins that were not confirmed can be modified to more accurately reflect the conditions in the field.

6.2.2 Hydraulic Data

For each basin that was delineated by the watershed program, a wash point was recorded on the tablet pc. The wash points included descriptions for channel type, bottom width, depth, side slope, wash composition and erosion potential as well as the exact location of the wash. This information will be used to determine accurate velocity and lag times used to model the peak runoff from each basin. At least one wash point was collected for each basin, while every wash was collected in basins that directly impact the rail alignment. The basins that directly impact the rail alignment will be broken down into smaller basins to more accurately determine the flow rate at each potential wash crossing.

6.2.3 Vegetation and Land Use

To accurately determine the runoff rates for each basin, it was essential to accurately describe the vegetation and land use in each area. Vegetation varied from small desert sage brush with only 5% total ground cover to Mesquite and Juniper tree cover with high desert grasses covering up to 50% of the ground. Land use ranged from no use to cattle grazing and agriculture. Individual areas were delineated directly onto the GIS maps using the tablet pc by creating polygons which could be edited with the required land use and vegetation cover. (The collected data is included on the Hydrologic Data DVD for this report.)

6.2.4 Soil Type

Soil type is the final requirement for calculating runoff values from a given basin. Soil types range from A, low runoff potential, to D, high runoff potential, with B and C in the middle. Soil types were verified by field personnel by visual inspection of the surface. Soil maps were overlaid from the NRCS and were checked in the field. Using the tablet pc, soil types were confirmed or modified to represent the conditions in the field. These values along with the above data that was collected in the field will be used to determine the peak runoff rates that impact the CRC.

7.0 WATERSHED ANALYSIS PLAN FOR PHASE 2

7.1 INTRODUCTION

The watershed analysis plan presents the methods and procedures to be utilized to generate the peak runoff rates and volumes needed for drainage facility design as well as information on other flood hazards such that measures to mitigate these hazards can be analyzed and designed. The Watershed Analysis Plan is divided into two sections. The first section presents the criteria to be used for analysis of flood flows and flood hazards. The second section presents the proposed watershed analysis scope (work tasks) needed to complete the watershed analysis portion of the work.

7.2 WATERSHED RUNOFF DETERMINATION CRITERIA

7.2.1 Introduction

Hydrologists rely on precipitation data, stream gauge data, and historic evidence of flood events to predict peak stream flows for various frequencies of runoff events. Many areas of the United States have over 50 years of frequently occurring precipitation and flood events upon which to make accurate statistical estimates of future peak flow occurrences. However, in the State of Nevada, the accuracy of said estimates is severely hampered by many factors including:

a) Sparsely located rainfall gauges: There are few (less than 12) rainfall gauges located within the CRC watersheds and most have less than 20 years of records, and then only daily (24 hour) rainfall data.

b) Sparsely located stream flow gauges. Within the CRC there are approximately 20 stream flow gauging stations. However, only 8 of these gauges have sufficiently correlated records upon which a regression equations have been formulated (USGS, 1994). All sites have less than 45 years of record.

c) Sparse storm events. Most of the study area receives less than 10 in of precipitation per year. Much of this precipitation occurs during the winter months as snow or low intensity rainfall. During the summer months, many areas experience only one or two thunderstorm events per year. This results in many streamflow gauges recording no flow for the entire year.

Analysis for determination of peak runoff flow rates necessitates the use of various methods to provide the most accurate estimate of the peak flow events. For this project, statistical analysis, regional regression analysis, and synthetic rainfall/runoff modeling will all be used and compared, where available and applicable, to provide the necessary peak runoff values for design of the CRC facilities.

7.2.2 Runoff Determination Issues

7.2.2.1 Flood Frequency

Floods will be simulated from severe storms; however, in arid regions severe storm frequency is not equivalent to flood frequency. Gauge records in southern Nevada often show numerous years with nearly zero stream flow. Smaller storms, even severe storms may produce little runoff. The frequency of storms needs to be adjusted to account for the conditional probability that runoff is near zero. For example, it may require a 120-yr storm to produce a 100-yr flood.

7.2.2.2 Reliability

All of the data for simulation of floods has measurement error. These errors are of two types: first, there is an at gauge error; and second, there is a spatial error (i.e. map accuracy). The main hydrologic modeling processes (precipitation, infiltration/storage, and surface runoff) have both types of errors. Sources of data provide estimates of parameter range and spatial accuracy, so such data should be explicitly incorporated into the model to develop confidence ranges. The limits of map accuracy should be adhered to in the modeling process.

7.2.2.3 Risk

The drainage design will address the risk of 100-yr flooding to the rail route. For drainage structures that cross the route (culverts and bridges) the design can be evaluated given the estimated 100-yr flood peak and volume. The designer may consider the uncertainty of the flood estimate, site conditions and other factors in the hydraulic analysis of the drainage structure.

The risk can also be affected by the configuration of the rail route. Rail routes that parallel streams are vulnerable to systematic failure. In a dynamic environment such as a river corridor, the width and depth of the channel can change dramatically in a major flood. This can result in the failure of one structure that leads to the failure of another downstream structure. For example, the failure of a rail embankment due to widening of the stream channel can result in the downstream failure of a cross culvert.

7.2.2.4 Model Testing

There are several choices for model testing. One method is a comparison of simulated model flood flows to the flow records at gauge sites located within the corridor. The number of gauges to test against could be increased by adding basins that are near the corridor to the modeling effort. Testing at gauges can help to address the issue of arid region flood frequency and associated storm magnitude.

A general level of testing can be accomplished by comparison of modeling results to National Flood Frequency (NFF) regression equations and the associated statistics (i.e. confidence limits). Note that these regression equations are developed for small basins (less than 50 sq mi) to mid-sized basins (less than 1000 sq mi) and may be too small for many of the CRC basins. The primary use of the NFF equations and statistics will be to evaluate model error, not to determine peak flow values.

Finally, peak discharge envelope curves are available that can be used as a general test. The purpose of this comparison is to determine if model error is within general understood statistical limits.

7.2.2.5 Validation

Data sources that have been compiled into the simulation model format should be reviewed through the quality assurance process. This process should track the originator of the data (the person responsible for compiling the source data into the model), an independent reviewer of the data, and the corrector (this can be the originator). Each data source should be identified by a unique name and digest (a hash of the file that provides a unique finger print of the file). Other metadata should be provided with the file that at a minimum provides source map accuracy and parameter confidence limits.

7.2.3 Statistical Analysis

Statistical Analysis will be performed on records from the approximate 20 stream flow gauges within the CRC watersheds. Analysis will be performed in accordance with the Bulletin 17B Methodology.

7.2.4 Regression Analysis

The USGS, 1994 regional regression equations provides the most current regional regression analysis available for watersheds covering the CRC. However, the lack of adequate data supporting this report within the CRC watersheds and the lack of inclusion of more recent data minimizes the reliability of estimations produced by this method. Thus, this information will not be used for this project.

7.2.5 Rainfall/Runoff Modeling

7.2.5.1 Modeling Classes

Today there are two distinct classes of hydrologic event simulation models: lumped parameter and distributed process. Distributed process models can simulate storm runoff at the USGS DEM scale of topographic mapping. This type of modeling facilitates the integration of other spatial data that is of a similar scale for soils and rainfall distribution. Distributed models are useful when runoff is not well confined or directed, such as on an alluvial fan. In arid regions, such areas are often accompanied by large transports of sediment, which also needs to be modeled.

Lumped parameter modeling is well suited to the modeling of organized basins with a hierarchy of tributaries. The scale of the sub-basins for lumped parameter modeling can be much larger, which reduces the amount of data to be managed. The analysis of large, well-organized basin for a few design points is best accomplished with a lumped parameter model. Lumped parameter models can be used to evaluate distributed conditions where the flow paths are better defined or uncertainty analysis can be used to evaluate multiple path options.

The hydrologic modeling of a transportation corridor requires the analysis of major stream crossings and streams that parallel the route. Between major crossings there will be smaller basins that are inter-fluvial basins. These basins are typically smaller than the basins that would normally be delineated as a model sub-basin. If the area is less than about 10 acres then it should be combined with another sub-basin.

Table 7-1
Recommended Hydrologic Models

Class	Application	Element Scale Range
Distributed Process Model	1. Poorly confined flows 2. Large alluvial fan drainageways	0.25 to 10.0 acres
Lumped Parameter Model	1. Hierarchical watersheds 2. Confined diversions 3. Multi-path analysis with uncertainty	10 acres to 10 sq mi
Small basin analysis	1. Local corridor drainage facilities	Less than 40 acres

Most of CRC routes can be evaluated with lumped parameter modeling. Routes over alluvial fan terrain should initially be modeled using multi-path analysis based on uncertainty analysis. The multi-path analysis should consider the likely capacity of the drainageways with sediment deposition and channel avulsion. Basins less than 10 acs should be aggregated into adjacent basins.

Distributed process modeling should be applied to large, complex alluvial fans that affect a substantial segment of the route (over 1.0 mile). Such a crossing will involve multiple structures and overlapping risks to the route that can be more economically evaluated using a distributed model. Sediment transport should be modeled. The morphology of the fan should be reviewed for areas with the potential to avulse or change direction due to topographic conditions.

Small basins along the corridor will need to be delineated for the design of local drainage facilities (typically small cross culverts and rail-side ditches).

The four components of the hydrologic cycle that are important for a hydrologic simulation of a storm runoff are:

1. Precipitation
2. Infiltration and incidental storage
3. Surface runoff
4. Drainage network

Precipitation is very important for hydrologic engineering in regions where few measurements of floods have been made and the development of flood discharges must be accomplished by synthetic methods. Infiltration and shallow surface storage is the portion of the precipitation that enters the ground or evaporates and is not available for runoff. Some infiltration may return by way of groundwater to become stream flow but generally is not an essential element in flood hydrology. Surface storage is water that is held in small puddles and small scale surface irregularities that ultimately infiltrates or evaporates. The drainage network consists of open channels, streams and rivers that concentrate and convey surface runoff. The density, gradient and shape of channels within the network greatly influence the movement of floods.

The patterns of the four dominant hydrologic elements are derived from various types of maps. As such, the various maps have the potential for error and inherent limits to accuracy.

7.3 RAINFALL/RUNOFF MODELING CRITERIA

The USACOE HEC-1 model will be utilized for modeling of the subject watersheds. The HEC-1 model will be coupled with GIS pre-processor and post-processor to automate the generation of input data and output reports.

7.3.1 Model Protocol

7.3.1.1 Units

The project shall be conducted in United States customary units (CU). The following standard unit types will be used for the project.

Table 7-2
Project Units

General Unit	Unit Type	CU Unit	Precision
Length	Structure Length	Ft	To the nearest 10th
	Overland/Sheet Flow Length	Ft	To the nearest ft
	Stream Branch Length	Mi	To the nearest 1000th
	Flow Depth	Ft	To the nearest 10th
	Rainfall Depth	In	To the nearest 100th
Rate	Infiltration Rate	In per hour	To the nearest 100th
	Rainfall Rate	In per hour	To the nearest 100th
	Flow Velocity	Ft per second	To the nearest 10th
Area	Basin Area (small)	Acs	Less than 160 acs
	Basin Area (large)	Sq mi	Greater than ¼ sq mi
Time	Hydrograph Duration	minutes	To the nearest minute
	Hyetograph Duration	minutes	To the nearest minute

7.3.1.2 Coordinate System

The large-scale basin mapping (watershed scale mapping) shall be derived from 1:24,000 scale topographic mapping obtained from the US Geological Survey. The topographic map shall be in the form of a DEM with a grid interval of 30 m (100 ft). The horizontal datum shall be Universal Transverse Mercator (UTM) Zone 11 NAD

83 and the vertical datum shall be NAVD 88. The estimated spatial accuracy of this topographic mapping is given in the following table. (Note: Since the UTM coordinate system is in metric the primary table units are ms.)

Corridor-scale mapping shall be derived from 1:6,000 scale aerial-topographic surveys. The source data shall be mass points and feature lines with a horizontal datum in UTM Zone 11 NAD 83 and a vertical datum in NAVD 88. If the corridor mapping is prepared as a DEM, the grid interval should be no smaller than 7.5 m (25 ft).

Table 7.3
Topographic Map Accuracy

Map Type	Scale	Radial Accuracy	Vertical Accuracy	Equivalent Contour Interval
Watershed Scale	1:24,000	14 m (45.6 ft)	1.85 m (6.1 ft)	6.1 m (20 ft)
Corridor Scale	1:6,000	3.4 m (11.0 ft)	0.46 m (1.5 ft)	1.5 m (5 ft)

7.3.1.3 Topographic Models

The watershed-scale topographic surfaces shall be developed as DEM on a uniform grid of 30 m (100 ft). Resolution of the DEM will not be sufficient to detect geomorphic features less than about 200 m (650 ft) as their primary dimension. This means that the watershed scale DEM should not be used within the corridor when it is necessary to evaluate detailed corridor features. However, the watershed scale topographic models are appropriate for evaluation of watershed runoff processes that pass through or along the corridor.

The corridor-scale topographic surfaces shall be developed as a triangulated irregular network (TIN) using surveyed mass points and breaklines. This model should have an approximate 200 m buffer beyond the extents of the corridor survey that is composed of adjacent watershed-scale grid points. This will permit the corridor-scale topographic models to be overlapped with the watershed-scale models. The TIN models will be used for detailed hydrologic simulation within the corridor, such as hydrologic analysis of alluvial fans, stream flow routing, or stream scour and erosion at corridor crossings where detailed cross sections are needed.

DEM models at the corridor scale shall be the result of sampling of the corridor TIN models. Grid density shall not exceed the accuracy of the original mapping (7.5 m or 25 ft). Likewise, depiction of contours for either the TIN or DEM models shall not exceed the accuracy of the topographic data source (see above table).

7.3.1.4 Precipitation Models

Precipitation

The precipitation models will be developed using the following procedure: 1) estimate point runoff and the associated confidence limits, 2) make a spatial distribution of the rainfall in accordance with the storm type (general or meso-scale), 3) determine locations for the storm center and direction of the storm pattern on the watershed, and 4) develop the temporal pattern and duration of the storm event.

Storm Frequency

Three storm frequencies will be analyzed for this project (see Table 7-4); the storm frequency that produces near zero flow, the 10-yr storm, and the 100-yr storm. The 10-yr storm runoff will be compared to stream channel morphology (the bank full flow) [Leopold, Luna B., Water, Rivers and Creeks, 1997, University Science Books, Sausalito, California]. The 10-yr storm runoff is used since more accurate estimates of 10-yr runoff can be obtained from the stream flow gauges than for the 100-yr event. The near zero flow event will be used to confirm curve number (CN) estimates.

Table 7-4

CRC Hydrologic Study Flood Frequencies

Flood Probability	Study Use
P_{zero}	Storm frequency at near zero stream flow at a design point.
P_{10}	Indicator probability for fluvial morphology.
P_{100}	Design frequency for corridor drainage structures.

Adjustment for Near Zero Flows

Floods will be simulated from storm runoff; however, in arid regions severe storm frequency is not equivalent to flood frequency. This is because the frequent smaller storms may have zero runoff. The magnitude of larger storms needs to be adjusted to account for the conditional probability runoff that is near zero.

$P' = (1 - P_z) \cdot P_s$ .... (Equation 1)

where: P' is the adjusted probability of a storm event,

Ps is the probability of the associated storm event, and
Pz is the probability of a storm event that produces near zero flow.

The adjustment factor will be determined from the analysis of gauge records at stream gauges near and within the corridor watersheds and simulation of storm runoff from these watersheds.

Alternatively, a series of randomly generated rain events could be used to simulate an annual peak basin stream flow. The stream flows could be statistically analyzed to calculate frequency distribution statistics.

Equation 1 offers a direct adjustment to the input rainfall using the base configuration of a basin model. This is approximate and a more refined approach would be to derive synthetic flows from multiple runs. However, the latter approach would require variation of all the major hydrologic elements of each model and would need to presume conditional probabilities for each element. The latter may not lead to realistic results, since such conditional probabilities are uncertain and might largely be no more than educated guesses.

The limitation of equation 1 is that is assumes that the frequency distribution for storms and floods are directly related.

For watersheds less than 175 sq mi, the average precipitation depth over the watershed will be used. The average depth will be computed by determining the point precipitation depth at the centroid of watershed and then reducing this value by a depth versus watershed area reduction relationship (see table 7.5).

Table 7-5
Precipitation Depth Reduction Factor versus Watershed Area

Watershed Area (sq. miles)	10	25	50	100	175
Reduction Factor	1.0	0.96	0.92	0.86	0.82

For watershed greater than 175 sq mi, a storm pattern will be used over the watershed. The point precipitation depth will be estimated at the location of the center of the storm. The depth area reduction relationship and spatial pattern will produce nearly the same average rainfall for a watershed area of up to 175 sq mi.

Precipitation Depth

NOAA Atlas 14 will be used to estimate the point precipitation values for a storm. This Atlas provides the most comprehensive and up-to-date analysis of rainfall data within the CRC watersheds. For basins less than 175 sq mi the point precipitation will be estimated at the centroid of the basin. For basins greater than 175 sq mi the precipitation will be estimated at the center of the storm pattern.

Where a spatial pattern of precipitation is used the precipitation depth for a sub-basin element will be computed from the weighted precipitation depths determined from the storm isopluvials.

Spatial Pattern

The spatial distribution of rainfall over a watershed will be represented by an elliptical pattern. The shape will be defined by a major axis that is 2.5 times the length of the minor axis. The initial isohyetal pattern for general and convective storms is given in the Table 7.6.

Table 7-6
Percent of Point Precipitation

Isohyetal Zone	Isohyetal Area (sq. miles)	Convective Storm	General Storm
A	10	100%	100%
B	25	93%	93%
C	50	87%	88%
D	100	81%	81%
E	175	75%	76%
F	300	58%	69%
G	450	45%	65%
H	700	36%	59%
I	1000	30%	55%
J	1500	22%	40%
K	2150	17%	29%
L	3000	13%	22%
M	4500	8%	14%
N	6500	3%	8%

O	10000	0%	3%

Storm Size

The convective storm size is estimated to be 200 sq mi and the general storm size is estimated to be 1000 sq mi. The fringe precipitation area for these storms extends beyond the nominal area of the storm size as can be seen by the precipitation pattern.

Orientation of the Storm

The primary orientation of convective storms is south to north (0 degrees as measured from north). The primary orientation of general storms is from southwest to northeast (45 degrees as measured from north).

Location of Storm Center

Initial centering of the storm center should coincide with the basin centroid. Additional trials shall be conducted to locate the storm center that gives the largest rainfall volume over the watershed and to locate the storm center that gives the largest peak flow at the design point.

Storm Tracking

The analysis of the effects of a storm tracking across a watershed is primarily used on larger watersheds where the aspect of the watershed parallels the typical storm track of the area under consideration. In Nevada, almost all of the major storm events typically track from west to east or southwest to northeast. However, the aspect of all the larger watersheds covering the CRC is generally from north to south. Thus, a fixed storm event will reasonably model the conditions expected in the CRC modeled watersheds.

Temporal Pattern

Appendix A.1 of the NOAA Atlas 14 will be used to develop the temporal distribution of severe precipitation.

Storm Duration

For thunderstorm events, a 24-hour rainfall event will be used with the peak precipitation occurring within the first hour of the storm event. The 24-hour event is suggested instead of a typical 3-hour or 6-hour thunderstorm event to provide better estimates of overall runoff volumes which may be needed for detention analysis (if and where applicable as a design solution).

7.3.1.5 Soils Model

Hydrologic soils data will be developed from the Nevada statewide soils map, subdivided into hydrologic soil types, and further verified with results from the collected field data. Where the collected field data conflicts with the hydrologic soils map, the map will be adjusted to reflect field conditions with appropriate documentation of the reason for the change and the area/extent of the change.

The composite infiltration parameters will be determined by spatially weighting the values of parameter for each HSG within the sub-basin element.

7.3.1.6 Vegetation Model

Vegetative cover and land use data will be developed from the state-wide vegetative cover map and land use coverage from watershed area aerial photographs. This data was reviewed with the collected field data. Where conflicts exist, the map will be adjusted to reflect field conditions with appropriate documentation of the reason for the change and the area/extent of the change.

7.3.1.7 Infiltration/Excess Precipitation Model

There are various methods, equations, and procedures available to determine the amount of precipitation which becomes surface runoff during a storm event as opposed to infiltration into the soil layers and surface extractions from vegetation and depressions. Most of these methods and equations attempt to relate the change over time in these infiltration and extractions depending on various parameters such as soil classification, soil depth, surface vegetation, and storm duration and intensity.

For the CRC watersheds, it is impractical to perform enough soil sampling within all the watersheds to obtain definitive soils characteristics. In contrast, there is sufficient reconnaissance level data available to generally characterize the soils, vegetation, and land use conditions of the subject watersheds.

A second important factor is the selected method's ability to mimic the historic and expected runoff conditions encountered in the subject watersheds. Existing data indicates that a significant portion of alluvial surface soils in Nevada either consist of surface rock features or buried caliche which reduces the soil horizon's ability to continuously infiltrate precipitation throughout the design storm events. Given the available data and the above described conditions, the Soil Conservation Service (SCS) CN method was selected as the most appropriate method for representing the rainfall/runoff conditions expected to occur within the CRC watersheds.

The SCS CN will be determined according to the hydrologic soils coverage in conjunction with the vegetative cover/land use map as matched to the CN description presented in the SCS TR-55 (USDA, 1986). The percent impervious option in HEC-1 will be utilized to represent the amount of rock outcrops and rock cover as well as other impervious surfaces which will generate immediate runoff upon application of precipitation. An antecedent moisture condition (AMC) II will be used for this project.

7.3.1.8 Drainage Network

Enumeration of Network Elements

The HEC-1 topology for a drainage network consists of branch elements and node elements. The node-branch labels shall encode the natural hierarchical structure of each watershed. A branch is defined by a seven character label in the following format: bbbhnnn, which indicates the basin number (bbb), the Horton order (h), and the branch enumeration (nnn). The node name in HEC-1 indicates a basic routing operation. The node is defined by a five character label in the following format: ffnnn, which indicates the operation type (ff) and the node enumeration (nnn).

7.3.1.9 Runoff Modeling

Unit Hydrograph Procedure

Several methods and designs are available for modeling the unit response of watersheds to incremental rainfall patterns. For the subject watersheds, there is insufficient information on unit watershed responses to perform a detailed unit hydrograph shaping analysis. Thus, the SCS unit hydrograph, which is based upon unit responses analysis across the United States, will be used for the runoff modeling of the CRC watersheds.

Estimates of Watershed Lag

The unit hydrograph procedure requires an estimate of the time required for 50% of the unit runoff to pass the point under consideration from the center of the unit rainfall excess. Several equations have been developed to estimate the watershed Lag. Both the United States Bureau of Reclamation (USBR) and the USACOE have utilized a form of the index equation L $L_{ca}/S^{0.5}$ for unit hydrograph Lag time estimates. For this project, the USBR's lag equation will be utilized based upon the data analyzed and included in the USBR Flood Hydrology Manual (USBR, 1989) for the Southwest Desert and Great Basin watersheds. The K_n factor, representing the average Manning's n value for the principal watercourses in the watershed, will be selected based upon field observations of similar principal watercourses. A conversion factor will then be applied to the USBR lag time to convert to an SCS lag time for use in the HEC-1 model.

Watershed Sizes

The size of the watersheds under investigation needs to balance the accuracy of the model with the accuracy of the data input for each watershed. With the use of high speed computers and automatic data generation software, the population of watershed data has been greatly accelerated such that more numerous watersheds can easily be analyzed, which produces more accurate peak flow estimates based upon the unit response of many smaller watersheds. For this project, watershed sizes will vary dependent upon the total area of the watershed as discussed in 7.2.5.1. Many of the subject watersheds are long and narrow with length to width ratios of 10 or 15 to 1. The use of smaller watersheds will be required in these areas to produce more accurate runoff results. The larger, long, and narrow watersheds will be divided into watersheds with length to width ratios of 5 to 1 or less.

Hydrograph Routing

Routing of the specific watershed hydrographs will be modeled using the Muskingham-Cunge method. This method is expected to more closely model the field observed effects of overbank storage, not just translation of the hydrographs in time.

7.4 PALEOHYDROLOGY

An additional factor to be considered in determining the reasonableness of the peak flow estimates is the existence of evidence of past flood events within the specific watersheds. This evidence could consist of high water marks, vegetation deposits, scour lines, and other evidence consistent with flood events. This evidence can be very difficult to identify in the field until a peak flow estimate is generated. Once the peak flow estimate is generated, the field photographs will be reviewed to determine if any physical evidence exists upon which the peak flow estimate can be verified or refined. Any evidence found will then be used as supplemental data in determining the need for additional study and/or analysis of the watershed.

7.5 ANALYSIS SCOPE AND PROCEDURES

The following procedure will be utilized in the determination of hydrologic information needed for the CRC hydrologic analyses.

1. Test Watershed Analysis: A test watershed will be utilized to perform initial data extraction, watershed model set-up, model data population, and initial model runs. The model results will be reviewed for errors and will be compared to previous analysis by others to determine reasonableness and verify accuracy.

The model results will also be compared to results from gauge and regional regression analysis to develop confidence intervals and error ranges for the watershed. The data necessary for this degree of analysis is available for only a few watersheds. The results will then be extrapolated to the remaining watersheds for use in determining the degree of confidence which can be placed on the hydrologic models for other watersheds.

This test analysis will also verify procedural accuracy and identify problems in model criteria, procedures, preparation, and application. Changes will be made, as necessary, to resolve all problems prior to application on a project-wide basis.

2. Model Parameters Sensitivity: A sensitivity analysis will be performed on all input parameters using approximate 10%, 50%, and 90% confidence interval range estimates to bracket the parameter sensitivities. This information will be used in a multiple parameter analysis to estimate confidence limits of the modeled results.

3. Watershed Modeling: Watershed models will be developed for all watershed areas impacting the CRC alignment. These models will be populated with the necessary analysis data and model runs will be performed.

4. Statistical Analysis: Statistical analysis of the existing stream gauge data will be performed and the results compared to flows generated by the hydrologic modeling process.

5. Regression Analysis: Peak flow determination from the previously described regression equations will be performed at the CRC design points, where applicable to assist in error band evaluation of results from other methodologies.

8.0 References

Adams, David K., 2003, Review of Variability in the North American Monsoon, United States Geological Survey, http://geochange.er.usgs.gov/sw/changes/natural/monsson

ANS (American Nuclear Society) 1992, American National Standard for Determining Design Basis Flooding at Power Reactor Sites. ANSI/ANS-2.8-1992. La Grange Park, Illinois: American Nuclear Society.

Blanton, J.O., III 1992, Nevada Test Site Flood Inundation Study, Part of U.S. Geological Survey Flood Potential and Debris Hazard Study, Yucca Mountain Site for United States Department of Energy, Office of Civilian Radioactive Waste Management. Denver, Colorado: U.S. Department of the Interior, Bureau of Reclamation.

Charlet, David A., January 7, 1998, Atlas of Nevada Mountain Ranges: Vegetation, University of Nevada Reno and Southern Nevada Community College Department of Science

Comrie, Andrew C., and Broyles, Bill, 2003, Precipitation Variability at High Spatial Resolution in the Desert Southwest, United States Geological Survey, http://geochange.er.usgs.gov/sw/changes/natural/precip

CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 2000. *Yucca Mountain Site Description.* TDR-CRW-GS-000001 REV 01 ICN 01. Las Vegas, Nevada: CRWMS M&O.

CRWMS M&O (Civilian Radioactive Waste Management System Management & Operating Contractor) 1998., Yucca Mountain Project Transportation EIS Maps, Rail Alignment Design Maps, BCB100000- 01717-0200-00002 REV 00. Las Vegas, Nevada

FEMA 19983, Flood Insurance Study, Nye County, Nevada, June, 1998.

FEMA, 1985, Flood Insurance Study, City of Caliente, Nevada, October 1985

FEMA, 1988, Flood Insurance Study, Lincoln County, Nevada, February, 1988

Glancy, P.A. and Beck, D.A. 1998, Modern Flooding and Runoff of the Amargosa River, Nevada, California, Emphasizing Contributions of Fortymile Wash.: Quaternary Geology of the Yucca Mountain Area, Southern Nevada, Field Trip Guide, Prepared for the 1998 Annual Meeting of the Friends of the Pleistocene, Pacific Cell, October 9-11, 1998. Taylor, E.M., ed. Pages 51-62. [Boulder, Colorado: Friends of the Pleistocene].

Kennedy/Jenks/Chilton, December 1990 (KJC, 1990, Hydrology Report - Yucca Mountain Rail Access Study – Caliente Route

Leopold, Luna B., <u>Water, Rivers and Creeks</u>, 1997, University Science Books, Sausalito, California

Nevada Division of Water Planning, 2005, Nevada Water Facts: Climate and Precipitation, http://water.nv.gov/Water%20planning/wat-fact/precip.htm

Nevada Division of Water Planning, 2005, Nevada Water Facts: Topography and Hydrogeography, http://water.nv.gov/Water%20planning/wat-fact/topo.htm

Nevada Division of Water Resources, 2005, Nevada Dam Inventory Database, http://water.nv.gov/IS/Dams/Dam_Queries.htm

NOAA, 2003, NOAA Atlas-14: Precipitation Frequency Atlas for the United States: Volume 1 - The Semiarid Southwest

Squires, R.R. and Young, R.L. 1984, Flood Potential of Fortymile Wash and Its Principal Southwestern Tributaries, Nevada Test Site, Southern Nevada. Water-Resources Investigations Report 83-4001. Carson City, Nevada: U.S. Geological Survey.

Stewart, J.H.,1980, Geology of Nevada: Nevada Bureau of Mines and Geology, Special Publication 4, 136 p.

Thomas, B.E., Hjalmarson, H.W., and Waltermeyer, S.D., 1997, Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States, United States Geological Survey

Topographic Engineering Center, 2005, National Inventory Dam Database, U.S. Army Engineer Research and Development Center, U.S. Army Corps of Engineers

Tueller, Dr. Paul T., Post, Dick, Noonan, Erin, September 20, 2002, Mapping Ecosystems Along Nevada Highways And The Development Of Specifications For Vegetation Remediation, Nevada Department of Transportation

U.S. Department of Energy (DOE), 1986, Yucca Mountain Site, Nevada Research and Development Area, Nevada, Vol. I, DOE/RW-0073, Washington, DC, 1986.

U.S. DOE, 1996, Final Environmental Impact Statement for The Nevada Test Site and Off-Site Location in the State of Nevada, DOE/EIS-0243

U.S. DOE, 2002, Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada

U.S. Energy Research and Development Administration (ERDA), 1977, Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada, ERDA-1551, Las Vegas, NV, 1977.

USBR, 1989, Flood Hydrology Manual, U.S. Department of Interior, Bureau of Reclamation, Washington, D.C., 1989

USDA, 1986, Urban Hydrology for Small Watersheds TR-55, U.S. Department of Agriculture, Soil Conservation Service, June 1986

USGS, 2004, USGS's cooperative Southwest Regional Gap Analysis Program, http://ftp.nr.usu.edu/swgap/landcover.html

WRC Engineering, Inc., 1993, Final Hydraulic Design Report for Amargosa River Bridge

WRC Engineering, Inc., December, 1989, Clark County Regional Flood Control District Technical Memorandum No. 2.

Figure 1-1: Caliente Rail Corridor - General Alignment Location Map

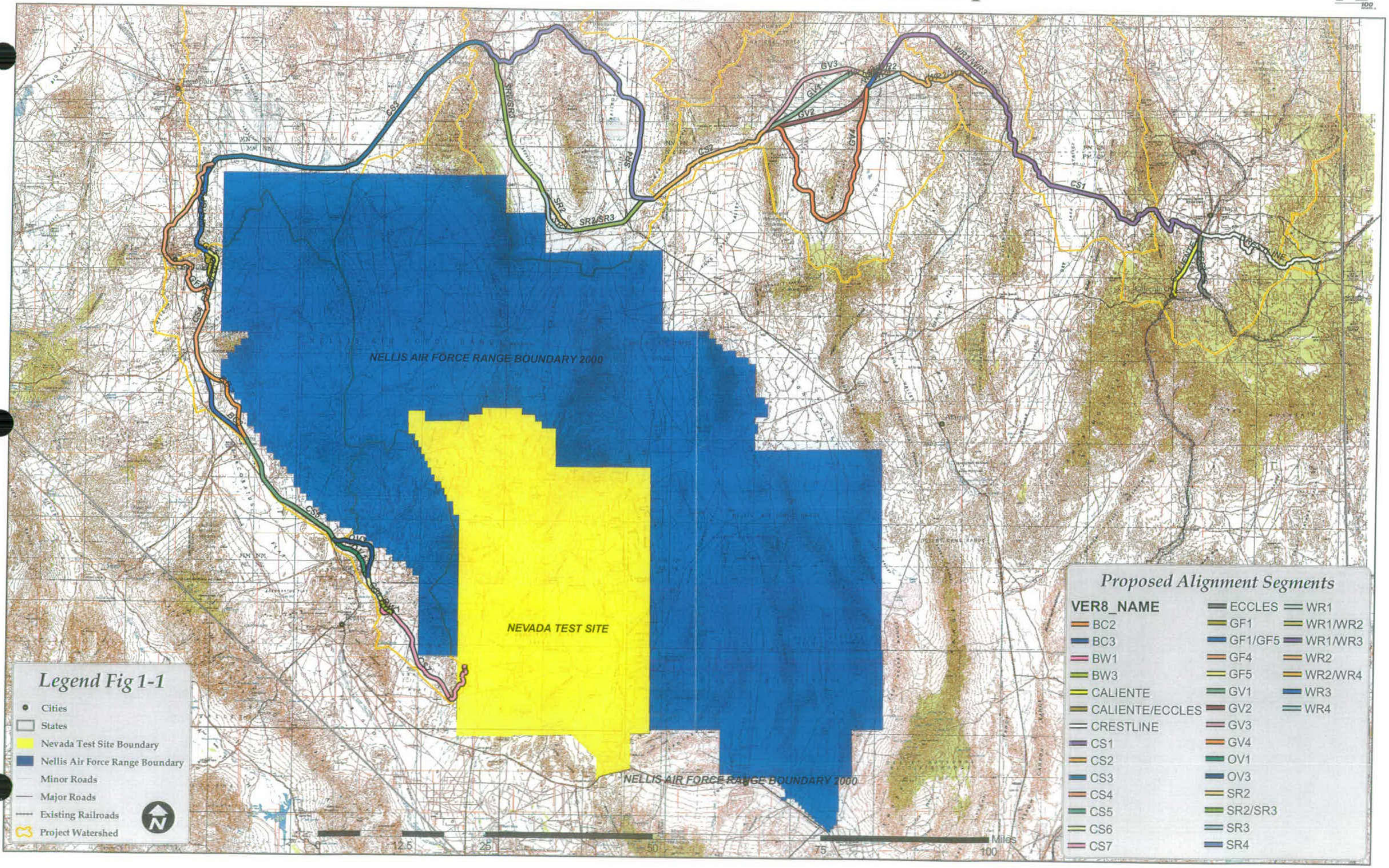


Figure 3-1: Caliente Rail Corridor - 100 Yr 6 Hr Storm Total

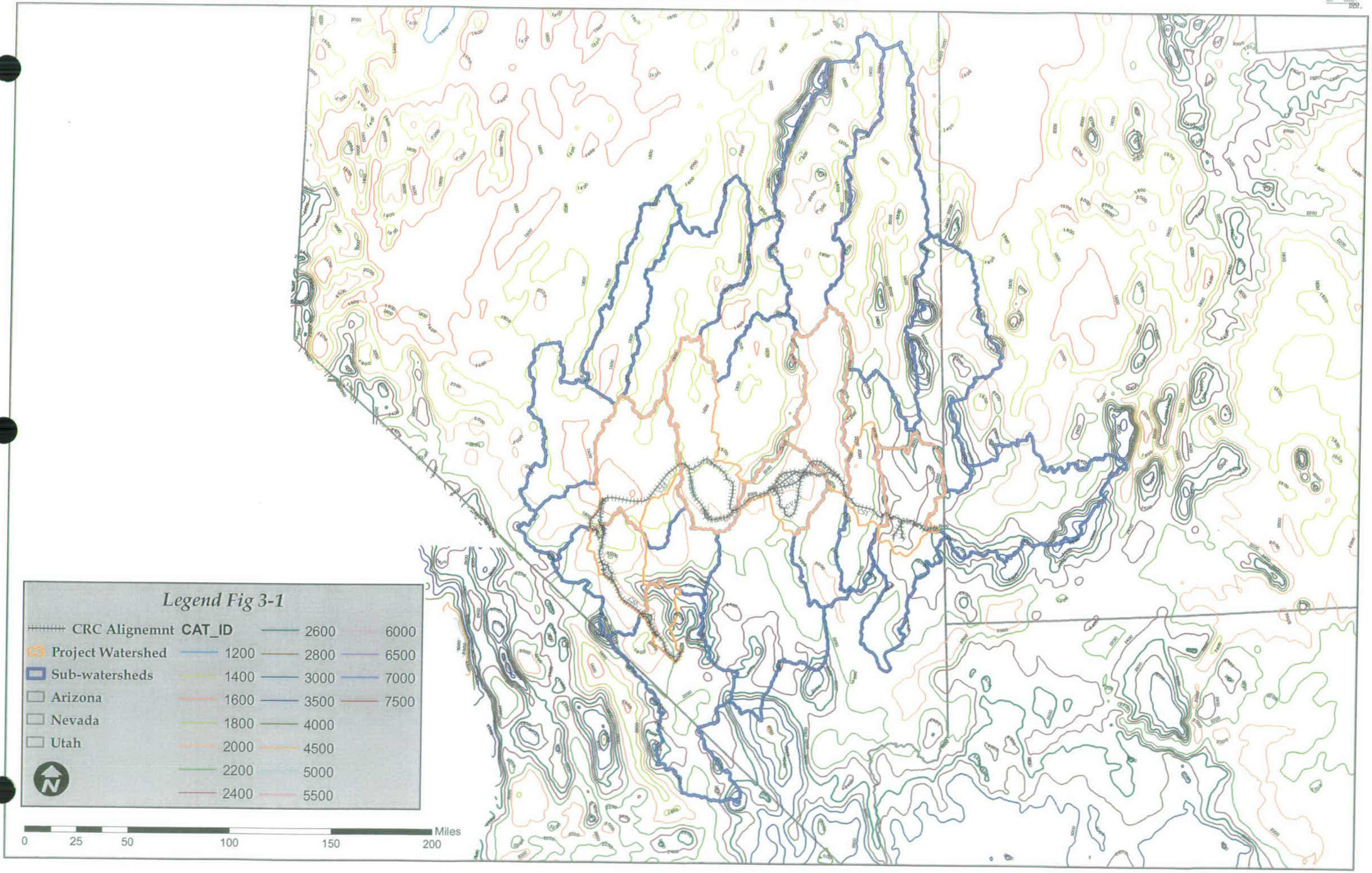


Figure 3-2: Caliente Rail Corridor - 100 Yr 24 Hr Storm Accumalation

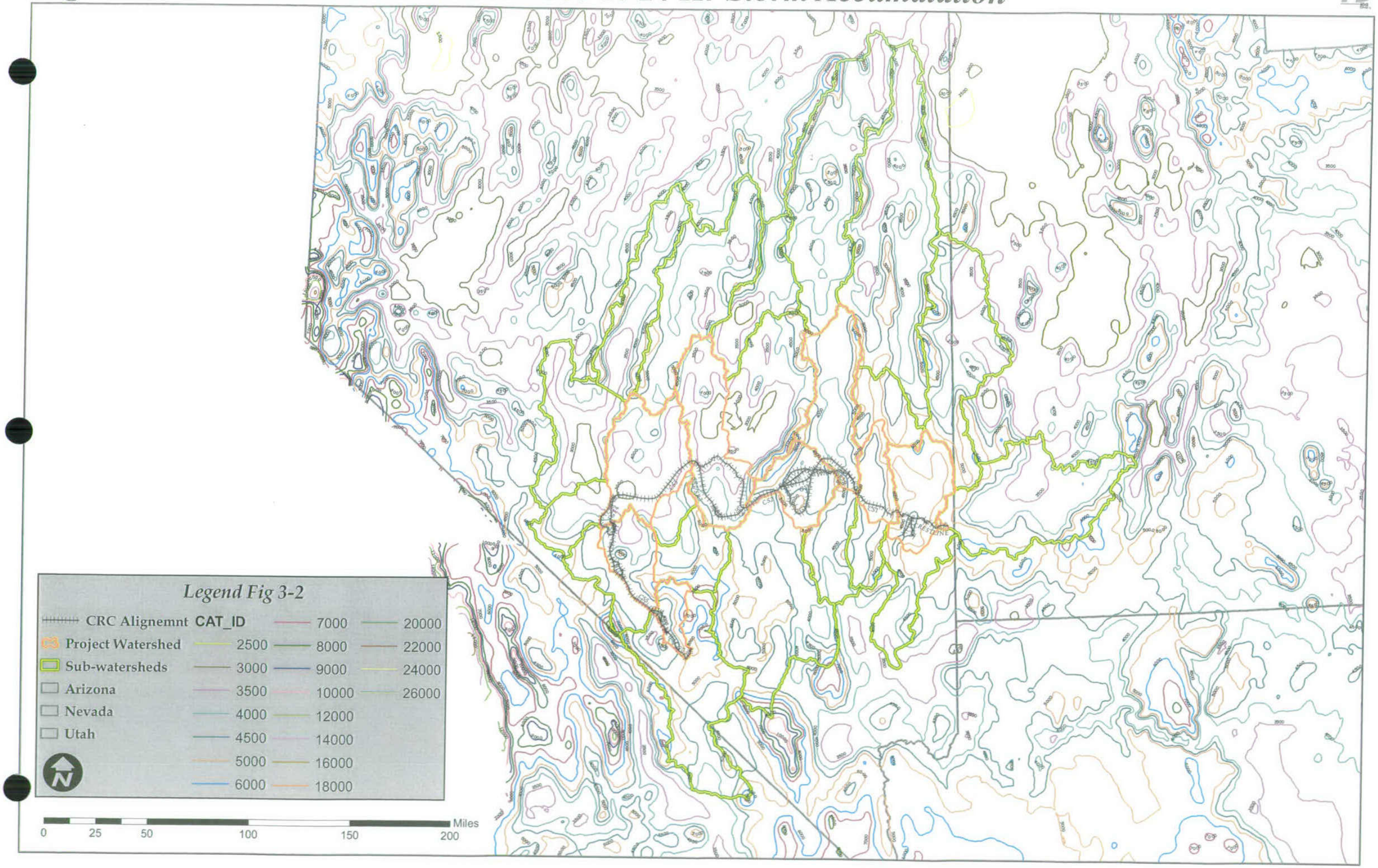


Figure 3-3: Temporal Distribution Regions

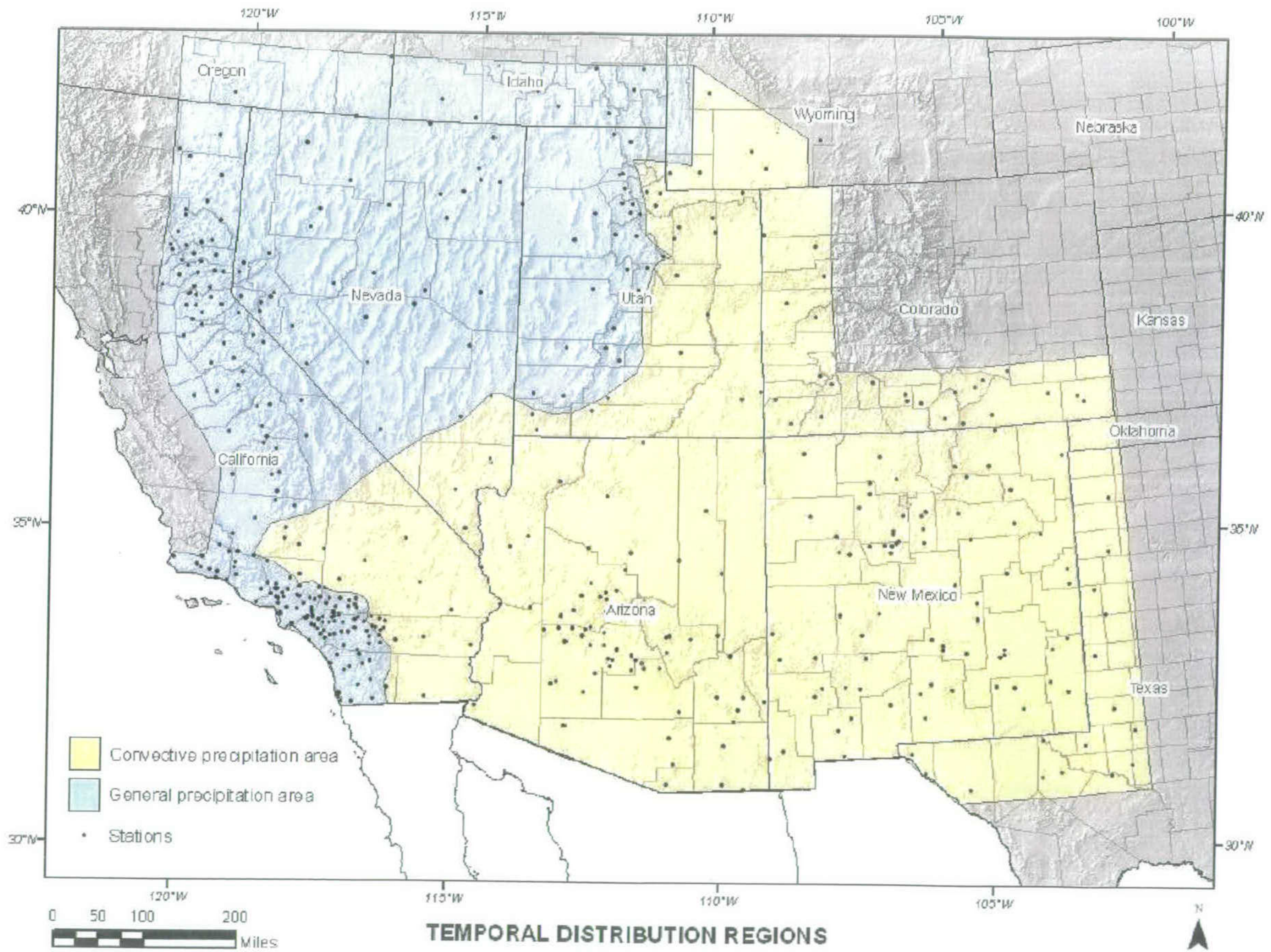
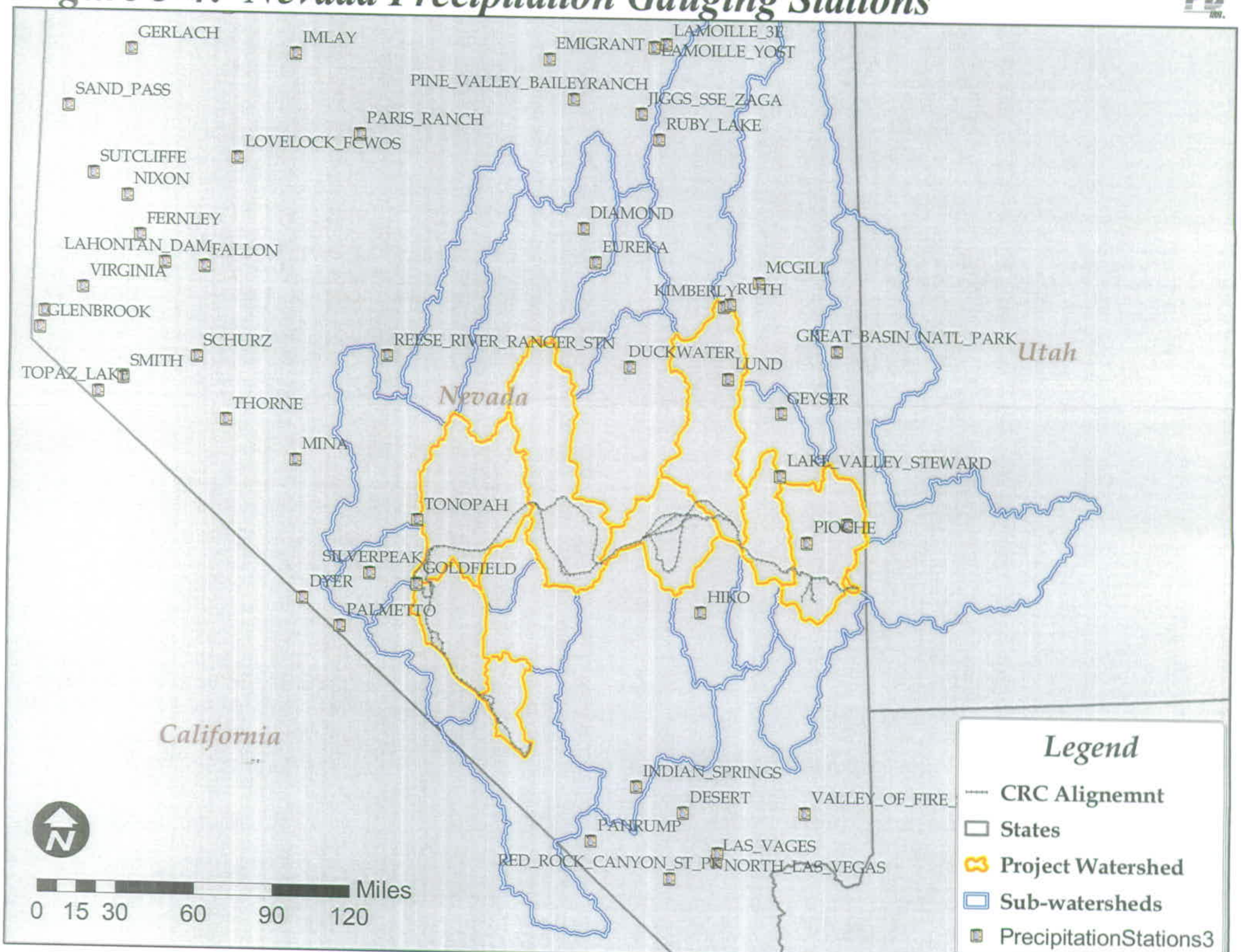


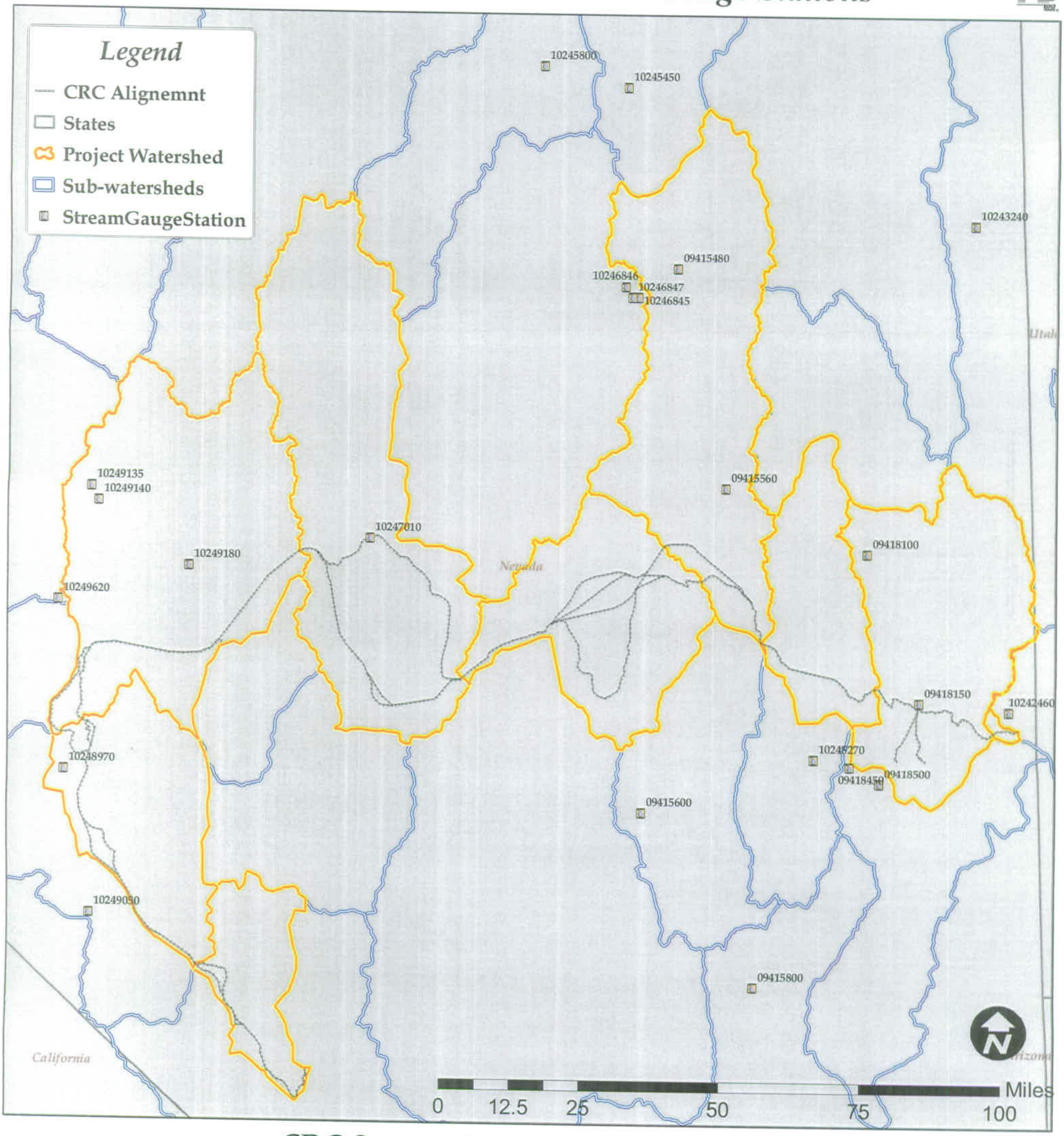
Figure 3-4: Nevada Precipitation Gauging Stations



CRC Precipitation Station Information

ID	Name	ST	LON	LAT	Elev_ft_	Begin_	End_	Data_Yrs	L_CV	L_CS	L_CK	Disc	FID	Daily_Regi
26-8349	TUSCARORA_WILLIAMS_RANCH	NV	-116.0667	41.35	6404	9/1888	11/1/1956	46	0.1771	0.1569	0.2538	1.48	0	4
26-8588	VALLEY_OF_FIRE_ST_PK	NV	-114.5142	36.4297	2000	Dec-72	12/1/2000	28	0.249	0.2165	0.1566	0.57	1	19
26-8761	VIRGINIA	NV	-119.6483	39.3128	6340	Apr-51	12/1/2000	46	0.1657	0.0368	0.1147	1.55	2	3
26-9122	WILKINS	NV	-114.75	41.4333	5643	Jul-48	5/1/1980	21	0.1645	0.1109	0.0681	1.25	3	4
26-2243	DESERT	NV	-115.3597	36.4378	2920	Apr-40	12/1/2000	61	0.2591	0.1165	0.1402	0.06	4	19
26-2296	DIAMOND	NV	-116.0494	39.7086	5970	Aug-79	12/1/2000	21	0.2183	0.2354	0.0301	1.98	5	11
26-2390	DUCKWATER	NV	-115.7158	38.9322	5610	Sep-66	9/1/2000	31	0.225	0.1576	0.1322	0.28	6	11
26-2394	DUFURRENA	NV	-119.0144	41.8681	4800	Oct-51	11/1/1999	44	0.2426	0.1337	0.0852	1.14	7	3
26-2431	DYER	NV	-118.0333	37.6167	4979	Feb-03	12/1/2000	63	0.2486	0.2044	0.1125	0.6	8	10
26-2656	EMIGRANT	NV	-116.3	40.65	5760	Jun-44	12/1/2000	53	0.211	0.2462	0.1568	0.24	9	11
26-2708	EUREKA	NV	-115.9619	39.5178	6540	5/1888	12/1/2000	77	0.2063	0.2648	0.2164	0.43	10	11
26-2780	FALLON	NV	-118.7811	39.4572	3965	Jun-03	12/1/2000	96	0.2186	0.1768	0.1735	0.17	11	10
26-2840	FERNLEY	NV	-119.25	39.6167	4163	Sep-44	5/1/1974	22	0.219	0.1374	0.2069	0.54	12	3
26-3090	GERLACH	NV	-119.3619	40.6506	3950	Jan-48	12/1/2000	29	0.2138	0.401	0.2896	2.37	13	3
26-3101	GEYSER	NV	-114.6361	38.6683	6020	Feb-04	12/1/2000	36	0.2474	0.1951	0.2564	1.35	14	11
26-3114	GIBBS	NV	-115.2122	41.5697	6000	Nov-52	12/1/2000	47	0.145	0.2001	0.1909	2.05	15	4
26-3205	GLENBROOK	NV	-119.9411	39.0753	6350	Jan-01	12/1/2000	62	0.2046	0.232	0.1434	0.47	16	9
26-3245	GOLCONDA	NV	-117.4881	40.9536	4415	2/1893	12/1/2000	104	0.2329	0.2122	0.1539	0.74	17	4
26-3285	GOLDFIELD	NV	-117.2331	37.7081	5690	Feb-06	12/1/2000	85	0.2746	0.1811	0.1484	0.41	18	10
26-3340	GREAT_BASIN_NATL_PARK	NV	-114.2267	39.0092	6830	Oct-37	12/1/2000	61	0.1763	0.1694	0.1525	0.65	19	11
26-3671	HIKO	NV	-115.2236	37.5581	3900	Mar-64	12/1/2000	37	0.2692	0.3121	0.1532	1.41	20	11
26-3957	IMLAY	NV	-118.1631	40.6564	4260	Mar-14	12/1/2000	82	0.2118	0.2327	0.2307	0.48	21	10
26-3980	INDIAN_SPRINGS	NV	-115.6833	36.5833	3123	Jan-39	6/1/1964	25	0.2881	0.1956	0.2309	0.99	22	19
26-4038	JARBRIDGE_4N	NV	-115.4333	41.9333	6168	Nov-16	6/1/1995	40	0.1755	0.0781	-0.0029	2.19	23	4
26-4095	JIGGS_SSE_ZAGA	NV	-115.6206	40.345	5800	Oct-78	12/1/2000	22	0.2271	0.2626	0.1973	0.14	24	11
26-4199	KIMBERLY	NV	-115.0333	39.2667	7234	Feb-28	5/1/1958	29	0.1591	0.1725	0.1546	1.5	25	11
26-4236	KINGS_RIVER_VALLEY	NV	-118.2253	41.7456	4240	Nov-56	12/1/2000	40	0.1951	0.2113	0.2085	0.12	26	4
26-4349	LAHONTAN_DAM	NV	-119.0644	39.4689	4150	Apr-11	12/1/2000	88	0.2432	0.2702	0.2364	0.48	27	10
26-4384	LAKE_VALLEY_STEWARD	NV	-114.65	38.3167	6350	Jan-71	11/1/1998	28	0.2067	0.1803	0.13	0.09	28	11
26-4392	LAMOILLE_3E	NV	-115.4333	40.7333	6306	Jul-16	8/1/1975	54	0.1872	0.154	0.1745	0.33	29	11
26-4394	LAMOILLE_YOST	NV	-115.5231	40.7178	5840	Oct-75	12/1/2000	25	0.2096	0.3603	0.3041	1.99	30	11
26-4429	LAS_VAGES	NV	-115.1333	36.1667	2011	6/1895	8/1/1956	53	0.2538	0.0598	0.1638	0.56	31	19
26-4700	LOVELOCK_FCWOS	NV	-118.5653	40.0664	3900	Jul-48	11/1/2000	49	0.2229	0.1363	0.1228	0.48	32	10
26-4745	LUND	NV	-115.0092	38.8625	5560	Aug-57	12/1/2000	43	0.1858	0.101	0.2745	2.21	33	11
26-4824	MALA_VISTA_RANCH	NV	-115.25	41.3167	5594	May-39	6/1/1965	26	0.2028	0.2138	0.0381	2.11	34	4
26-4858	MARLETTE_LAKE	NV	-119.9167	39.1667	8005	Dec-13	7/1/1952	25	0.1703	0.0683	0.1381	1.42	35	9
26-4950	MCGILL	NV	-114.7764	39.4014	6270	1/1892	12/1/2000	93	0.2137	0.2757	0.2237	0.38	36	11
26-5168	MINA	NV	-118.1058	38.3867	4550	3/1896	12/1/2000	104	0.25	0.1608	0.1994	0.43	37	10
26-5352	MONTELLO_2_SE	NV	-114.1728	41.2428	4900	4/1895	12/1/2000	103	0.199	0.2284	0.2555	0.76	38	11
26-5392	MOUNTAIN_CITY_RS	NV	-115.9653	41.8375	5650	Feb-55	11/1/1999	45	0.2152	0.2594	0.1048	1.15	39	4
26-5605	NIXON	NV	-119.35	39.8333	3904	May-28	11/1/1974	36	0.2506	0.2714	0.2645	0.95	40	3
26-5691	NORTH_FORK_MNTC_STN	NV	-115.8167	41.4833	6204	Nov-09	10/1/1970	49	0.1931	0.1736	0.2145	0.53	41	4
26-5705	NORTH_LAS_VEGAS	NV	-115.1231	36.2108	1880	Feb-51	12/1/2000	49	0.19	-0.0505	0.1423	2.5	42	19
26-5818	OROVADA_4_WSW	NV	-117.8333	41.55	4290	Aug-11	12/1/2000	85	0.1788	0.1489	0.1596	0.33	43	4
26-5890	PAHRUMP	NV	-116.0031	36.2786	2674	Mar-14	12/1/2000	52	0.2968	0.3085	0.2083	0.91	44	19
26-5931	PALMETTO	NV	-117.7667	37.4667	5906	3/1890	9/1/1951	22	0.2794	0.0945	0.08	1.56	45	10
26-6005	PARADISE_VALLEY1	NV	-117.5478	41.5022	4675	2/1894	12/1/2000	89	0.1963	0.1902	0.1268	0.17	46	4
26-6055	PARIS_RANCH	NV	-117.6833	40.2167	4140	Jul-66	10/1/1991	25	0.1865	0.1872	0.1178	1.52	47	10
26-6242	PINE_VALLEY_BAILEYRANCH	NV	-116.12	40.4294	5047	Oct-56	12/1/2000	43	0.2245	0.2863	0.2104	0.29	48	11
26-6252	PIOCHE	NV	-114.4661	37.9444	6180	1/1888	11/1/2000	71	0.2225	0.2368	0.1517	0.13	49	11
26-6504	QUINN_RIVER_CROSSING	NV	-118.4333	41.5667	4091	Feb-01	3/1/1951	28	0.2374	0.3038	0.2644	1.11	50	4
26-6691	RED_ROCK_CANYON_ST_PK	NV	-115.4603	36.0686	3780	May-77	12/1/2000	24	0.2882	0.3578	0.306	1.05	51	20
26-6746	REESE_RIVER_RANGER_STN	NV	-117.4667	38.9833	6649	Apr-72	12/1/2000	27	0.1683	0.1142	0.0265	1.7	52	11
26-7123	RUBY_LAKE	NV	-115.4928	40.2028	6010	Jan-40	12/1/2000	60	0.1964	0.2611	0.1264	1.01	53	11
26-7175	RUTH	NV	-114.9875	39.28	6840	Jun-58	11/1/2000	36	0.1958	0.141	0.0966	0.33	54	11
26-7261	SAND_PASS	NV	-119.8	40.3167	3904	Oct-13	9/1/1971	52	0.2186	0.182	0.1734	0.05	55	3
26-7284	SAN_JACINTO	NV	-114.6833	41.8833	5203	Sep-04	9/1/1948	43	0.1914	0.2079	0.2556	0.73	56	4
26-7358	SCHURZ	NV	-118.8167	38.95	4124	Jan-20	4/1/1957	36	0.2144	0.3116	0.2764	1.42	57	10
26-7443	SHELDON	NV	-119.6333	41.85	6506	Jul-33	2/1/1972	38	0.1721	0.1547	0.1787	0.66	58	3
26-7463	SILVERPEAK	NV	-117.5653	37.7619	4260	Oct-67	12/1/2000	33	0.2676	0.3763	0.2596	2.42	59	10
26-7609	SMITH	NV	-119.3333	38.8167	4754	Jul-08	9/1/1966	57	0.3041	0.3134	0.2066	2.01	60	10
26-7750	SPRING_VALLEY_ST_PK	NV	-114.18	38.0406	5950	Aug-74	12/1/2000	26	0.1791	0.1488	0.3013	2.47	61	11
26-7873	SULPHUR	NV	-118.6667	40.9	4042	Sep-14	1/1/1953	36	0.2646	0.1064	0.0666	2.42	62	3
26-7953	SUTCLIFFE	NV	-119.5983	39.9503	3900	Jun-67	12/1/2000	28	0.1911	0.2024	0.2138	0.41	63	3
26-8034	THORNE	NV	-118.6	38.6	4203	Apr-14	5/1/1950	34	0.2425	0.1253	0.1061	0.59	64	10
26-8160	TONOPAH	NV	-117.2333	38.0667	6024	May-02	[illegible]/1954	31	0.2205	0.1184	0.1288	0.48	65	11
26-8186	TOPAZ_LAKE	NV	-119.51	38.7319	5105	Jul-57	[illegible]1985	26	0.1907	0.1708	0.2921	2.68	66	10

Figure 3-5: Caliente Rail Corridor - Stream Gauge Stations



CRC Stream Gauge Station Information

FID	STATNUM	STATNAME	FLDREG	LAT	LONG	YRSRCRD	DRNGARE	MBE_FT	MAP_IN	MAE_IN
0	09415480	White River Tributary near Preston, Nev.	6	38.892	-115.194	20	26	6560	10	43.5
1	09415560	White River Tributatry near Sunnside, Nev	6	38.325	-115.045	15	20	6240	10.8	40
2	09415600	Pahragut Vally Tributary near Hiko, Nev.	6	37.489	-115.336	18	17	5750	10	54.8
3	09415800	Muddy River Tributary near Alamo, Nev.	6	37.033	-114.981	18	2	3340	6	57.6
4	09418100	Patterson Wash Tributary near Pioche, Nev.	6	38.15	-114.586	18	5	6250	10.2	43.3
5	09418150	Caselton Wash near Panaca, Nev.	6	37.763	-114.429	19	70.2	5830	6.9	52.4
6	09418450	Meadow Valley Wash Tributary near Caliente,	6	37.6	-114.658	18	0.5	5970	8	55
7	09418500	Meadow Valley Wash near Caliente, Nev.	6	37.556	-114.564	32	1670	6180	7.5	55
8	10242460	Escalante Valley Tributary near Panaca, Nev	6	37.736	-114.139	18	7.9	6790	9.1	50.1
9	10243240	Baker Creek at Narrows, near Baker, Nev.	6	38.99	-114.21	23	16.4	9500	16.5	39.8
10	10245270	Drylake Valley tributary near Caliente, Nev	6	37.622	-114.773	15	11	5910	7.5	55
11	10245450	Illipah Creek Tributary near Hamilton, Nev	6	39.36	-115.351	25	5.47	7100	12	52.4
12	10245800	Newark Valley Tributary near Hamilton, Nev	6	39.417	-115.631	25	157	6920	10.3	49.6
13	10246845	Current Creek Tributary near Current, Nev.	6	38.819	-115.326	20	3.13	6970	10	52.7
14	10246846	Little Current Creek near Currant, Nev.	6	38.847	-115.367	20	12.9	8280	13.5	55.3
15	10246847	Currant Creek below Little Currant near Cur	6	38.82	-115.345	15	30	7850	13.7	54.1
16	10247010	Hot Creek Tributary near Warm Springs, Nev.	6	38.2	-116.217	17	0.77	5300	6	42.9
17	10248970	Stonewall Flat Tributary near Goldfield, Ne	6	37.594	-117.21	20	0.53	5630	6	52.9
18	10249050	Sarcobatus Flat Tributary near Springdale,	6	37.222	-117.126	21	37.1	5140	7.7	55.1
19	10249135	San Antonio Wash Tributary near Tonopah, Ne	6	38.327	-117.124	19	3.42	6920	8.9	39
20	10249140	Ralsoton valley Tributary near Tonopah, Nev	6	38.29	-117.1	21	0.2	5980	6	45
21	10249180	Saulsbury Wash near Tonopah, Nev.	6	38.125	-116.808	21	56	6810	12	41.4
22	10249620	Big Smokey Valley Tributary near Tonopah, N	6	38.031	-117.231	21	2.39	6100	6	50.7

Figure 3-6: Caliente Rail Corridor - Field Verified Vegetation

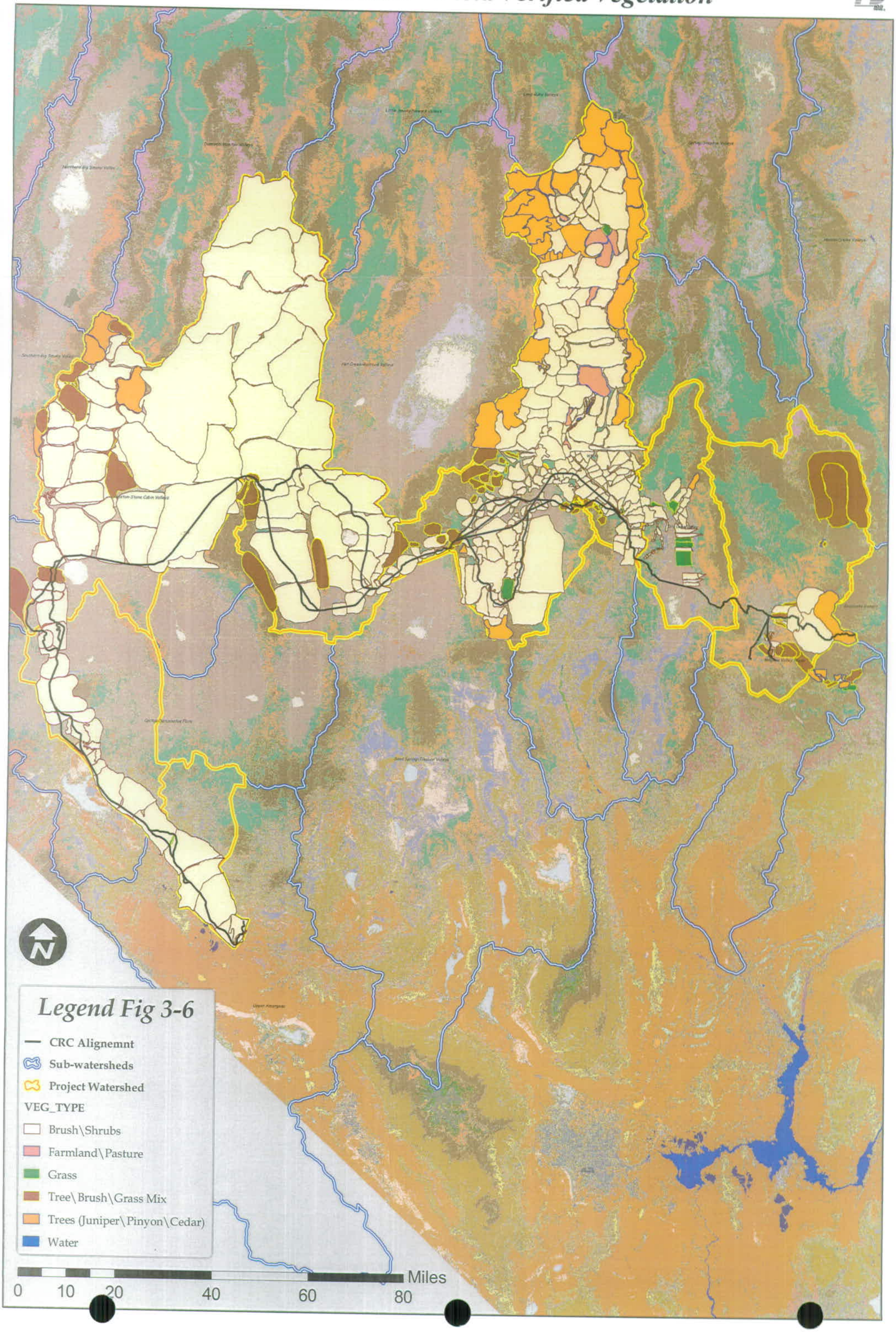
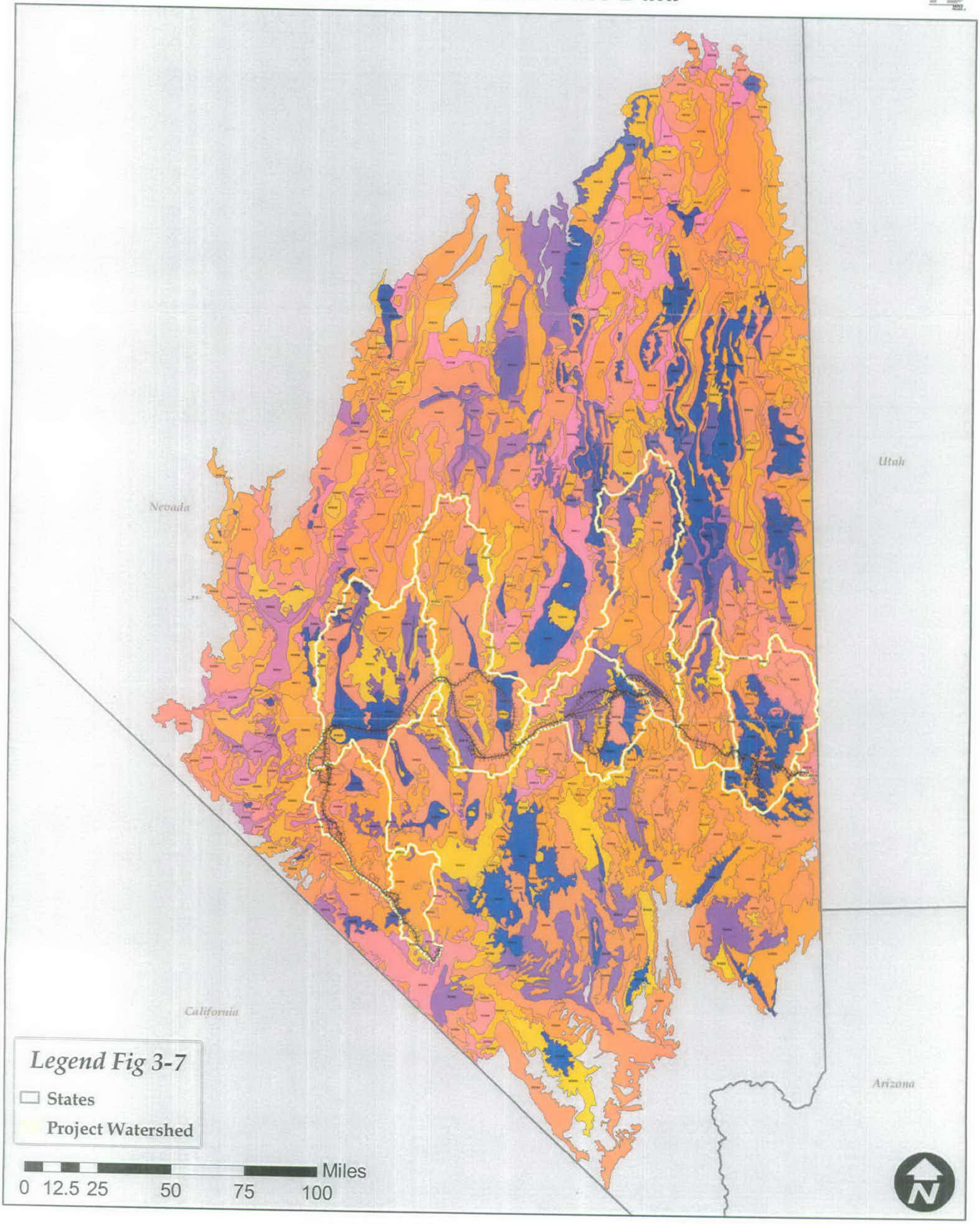


Figure 3-7: Caliente Rail Corridor - Soils Base Data



Soil ID - Composition Name

MUID_COMPN

- NV012 - CAGLE
- NV024 - HYMAS
- NV025 - LIEN
- NV026 - BATAN
- NV035 - ARMESPAN
- NV036 - BLIMO
- NV037 - ABGESE
- NV038 - ABGESE
- NV039 - ABGESE
- NV040 - BREKO
- NV041 - BATAN
- NV042 - BELTED
- NV043 - BATAN
- NV044 - BROYLES
- NV045 - BATAN
- NV046 - BLIMO
- NV047 - ARMESPAN
- NV048 - BLIMO
- NV049 - GEER
- NV055 - ARMESPAN
- NV088 - ARMESPAN
- NV089 - BYLO
- NV090 - ARMESPAN
- NV093 - DUFFER
- NV095 - CAVEHILL
- NV098 - JARBOE
- NV099 - EASYCHAIR
- NV104 - HUNNTON
- NV105 - BETRA
- NV106 - DONNA
- NV115 - CAVEHILL
- NV118 - BULLUMP
- NV119 - AKLER
- NV120 - HACKWOOD
- NV123 - HAYPRESS
- NV146 - BATAN
- NV148 - BILBO
- NV149 - DONNA
- NV150 - CHIARA
- NV153 - BANCY
- NV154 - GRAVIER
- NV156 - CLEAVAGE
- NV158 - AKLER
- NV159 - AFFEY
- NV161 - AMTOFT
- NV162 - AGASSIZ
- NV163 - AGASSIZ
- NV164 - SWINGLER
- NV165 - XICA
- NV166 - EASTWELL
- NV168 - URSINE
- NV170 - URSINE
- NV171 - GOLLAHER
- NV172 - ZIMBOB
- NV173 - IZAR
- NV174 - SONDOA
- NV175 - SEGURA
- NV176 - CLEAVAGE
- NV177 - OCALA
- NV178 - OROVADA
- NV200 - NUPPER
- NV202 - TENCEE
- NV203 - WEISER
- NV204 - KYLER
- NV205 - CAVE
- NV206 - MORMON MESA
- NV207 - ANTHONY
- NV209 - AKELA
- NV213 - BLUEPOINT
- NV215 - MOKIAK
- NV216 - PAUNSAUGUNT
- NV221 - ALKO
- NV223 - CLIFFDOWN
- NV224 - STEWVAL
- NV230 - PIOCHE
- NV231 - JOLAN
- NV232 - BADLAND
- NV233 - EAGLEPASS
- NV234 - ACANA
- NV235 - ACANA
- NV236 - PIOCHE
- NV237 - AKELA
- NV238 - ALKO
- NV242 - ARIZO
- NV244 - ABOTEN
- NV256 - CANUTIO
- NV301 - BELCHER
- NV302 - AQUIC CALCIORTHIDS
- NV303 - ANNAW
- NV304 - ARIZO
- NV305 - ARMESPAN
- NV306 - BLACKTOP
- NV307 - ADVOKAY
- NV308 - ADVOKAY
- NV309 - BELLEHELEN
- NV310 - ADVOKAY
- NV311 - EAGLEPASS
- NV312 - ENTERO
- NV313 - URSINE
- NV314 - ARMOINE
- NV315 - ALCAN
- NV316 - FUEGOSTA
- NV317 - BELCHER
- NV324 - ANNAW
- NV327 - ACANA FAMILY
- NV330 - ARGALT
- NV331 - ARMESPAN
- NV381 - CIRAC
- NV383 - BESHERM
- NV384 - ALKO
- NV385 - ARIZO
- NV387 - COMMSKI
- NV388 - CIRAC
- NV389 - ARIZO
- NV390 - AKELA
- NV392 - BLUEPOINT
- NV393 - BLUEPOINT
- NV394 - AGON
- NV396 - BLUEWING
- NV400 - MINNEHA
- NV402 - BATAN
- NV403 - BUBUS
- NV405 - BATAN
- NV407 - MCCONNEL
- NV408 - ALLOR
- NV409 - AKERCAN
- NV412 - ALLOR
- NV413 - ALLOR
- NV416 - ATLOW
- NV417 - AKERUE
- NV418 - CLANALPINE
- NV419 - BELATE
- NV420 - PACKER
- NV421 - HAPGOOD
- NV422 - ALLOR
- NV423 - BEANFLAT
- NV424 - NADRA
- NV425 - BROYLES
- NV426 - BROYLES
- NV427 - ADOS VARIANT
- NV428 - ATRYPA
- NV429 - ATRYPA
- NV430 - CHAD
- NV431 - BLUEWING
- NV432 - ALLKER
- NV433 - BOSCO
- NV435 - BADLAND
- NV438 - CHEN
- NV463 - BELATE
- NV471 - ATTELLA
- NV472 - ALLOR
- NV473 - ATTELLA
- NV489 - BARTINE
- NV490 - LONE
- NV491 - DIANEV
- NV492 - RATTO
- NV493 - ALHAMBRA
- NV494 - NAYPED
- NV497 - ADOS
- NV500 - HYMAS
- NV501 - PINTWATER
- NV502 - ROIC
- NV503 - QUIMA
- NV504 - WARDENOT
- NV505 - VIGUS
- NV506 - STUMBLE
- NV507 - LAYVIEW
- NV508 - REBEL
- NV509 - UMBERLAND
- NV510 - UNSEL
- NV511 - BELLEHELEN
- NV512 - KEEFA
- NV513 - KYLER
- NV514 - CANDELARIA
- NV515 - GABBVALLY
- NV516 - ARMESPAN
- NV517 - TITIACK
- NV518 - ZADVAR
- NV519 - HANDPAH
- NV520 - REBEL
- NV521 - CIRAC
- NV522 - LOGRING
- NV523 - UNSEL
- NV524 - DOWNEYVILLE
- NV526 - PLAYAS
- NV527 - PLAYAS
- NV536 - ROCK OUTCROP
- NV539 - BLACKMOUNT
- NV544 - ST. THOMAS
- NV545 - ARIZO
- NVW -

Figure 5-1: Caliente Rail Corridor - Project Subwatershed Calculated Areas